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ORIGINAL ARTICLES.

I.—Description of the Cretaceous Saw-Fish *Sclerorhynchus atavus*.

By Arthur Smith Woodward, F.L.S., F.G.S.

IN the "Catalogue of Fossil Fishes in the British Museum" (pt. i. 1889, p. 76, pl. iii. fig. 1), the imperfect rostrum of a Selachian fish from the Upper Cretaceous of Mount Lebanon was described under the new generic and specific name of *Sclerorhynchus atavus*. Presenting some resemblances to the rostrum both of the typical saw-fish (*Pristis*) and of *Pristiophorus*, hesitation was expressed in determining the systematic position of the genus to which the fossil pertained; but from the apparently complex nature of the rostral cartilages and the absence of extended prepalatines, it was deemed advisable to place the fish provisionally in the family of Pristidæ. A further description of the extremity of the rostrum in 1889,[1] though pointing to no definite conclusion, also appeared to favour the same view; and the unexpected discovery of another piece of rostrum among the Teleostean fishes in the British Museum at the same time led the writer to hope that the trunk of *Sclerorhynchus* might soon be identified. A careful study of the new specimen in the light of other Lebanon fossils in the British Museum, has at last realized this hope, and the affinities of *Sclerorhynchus atavus* may now be discussed on the basis of a tolerably complete skeleton.

As some of the principal specimens under discussion have already been described and figured, it will suffice on the present occasion merely to publish the accompanying restored outline of the fish (see p. 531). The trunk proves to be that already described under the name of *Squatina crassidens*;[2] and the discrepancies in the dentition and branchial apparatus between this fish and the typical *Squatina*, noted in the original description are thus explained. The absence of all indications of the freely ascending portions of the pectoral arch is also noteworthy in this connection; though the arch is not well shown under any circumstances.

Enumeration of Specimens.

Before, however, dealing with the skeletal characters of *Sclerorhynchus*, it is necessary to state precisely the nature of the evidence

[1] Proc. Zool. Soc. 1889, pp. 449–451, woodcut.

[2] Catal. Foss. Fishes, B.M., pt. i. 1889, p. 69, pl. ii.

by which the rostrum and trunk are proved to pertain to one and the same fish. The specimens are three in number, all in the British Museum, and may be enumerated as follows :—

(1) No. 53663. A much crushed rostrum, showing part of the mouth at its base, having teeth identical with those of the type-specimen of *Squatina crassidens*, and also one complete propterygial cartilage of the pectoral fin identical with that of the same type-specimen.

(2) No. 49518. Imperfect abdominal region identical with that of *Squatina crassidens*, showing patches of large, strongly calcified tesseræ, exactly resembling those of the rostral cartilages of *Sclerorhynchus*, and unknown in any other Lebanon fish.

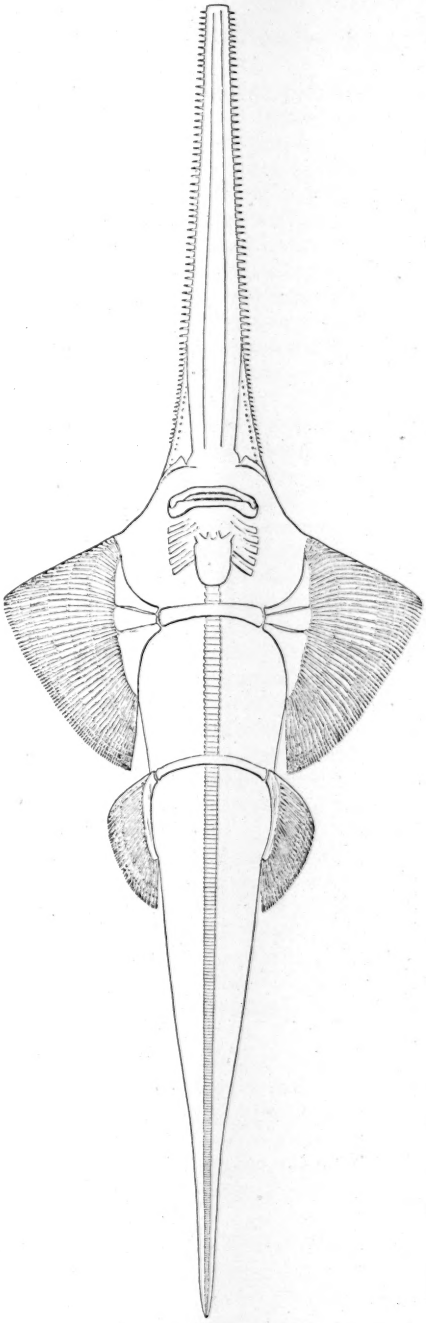
(3) No. 49547. Middle portion of fish, undoubtedly *Sq. crassidens*, displaying teeth and pectoral propterygium identical with those of No. 53663, and showing a detached patch of the characteristic rostral cartilage.

The general form and proportions of the trunk in the restoration are based upon the type-specimen of *Squatina crassidens*; while the proportions of the rostrum are inferred from the type-specimen of *Sclerorhynchus atavus*, and the tip of a small rostrum of a similar kind in the Paris Museum of Natural History.[1] Some details are added from other imperfect fossils noticed in the British Museum Catalogue.

Description.

Head.—The rostrum seems to have occupied not less than one-third of the total length of the fish, and its length equals about five times its maximum width at the base. If the Paris specimen be correctly interpreted as the extremity of the snout, the median rostral cartilage is shown to extend throughout its length; and the pair of broad lateral cartilages, fixed at the base between the anterior part of the nasal capsules and the narrow median cartilage, soon begins to occupy the whole of the space between this cartilage and the toothed margin of the blade on each side. The integument extends up the base of the rostrum in such a manner that there is no sharp line of demarcation between the head and the "saw"; while a gradual passage can even be observed between the ordinary dermal tubercles of the body and the elongated teeth arranged in a single regular series on each lateral rostral border. None of these teeth are fixed in sockets of the cartilage; but each comprises a high, round, crimped base, fixed in the skin in the usual manner, with a long, enamelled, exserted portion, compressed to an anterior and posterior acute edge. On the anterior border of each nasal capsule there is a sharply-defined, well-calcified triangular extension, apparently to be regarded as an abbreviate prepalatine cartilage; and amid the indecipherable remains of the cranium behind, the form and proportions of the jaws are distinguishable, as given in the figure. Several series of teeth seem to have been simultaneously functional in the jaws, and they are uniform in character. Each

[1] Proc. Zool. Soc. 1889, p. 450, woodcut.



Outline-restoration of *Sclerorhynchus atavus*, A. S. Woodward.
About one-fifth natural size. Upper Cretaceous, Mount Lebanon, Syria.

tooth is broad and acuminate, compressed antero-posteriorly, and fixed upon a depressed base; the crown is marked by large vertical wrinkles, and its median portion is more or less produced downwards anteriorly over the root.[1]

Branchial Apparatus.—The branchial arches are only seen imperfectly from below in one specimen (B.M. No. 49546), and this furnishes the evidence for our restoration. The great broad basibranchial plate exhibits at its anterior margin evidence of two pairs of forwardly directed processes, a delicate inner pair somewhat convergent in front, and a larger outer pair divergent. The five hypobranchial cartilages on each side are nearly uniform in size; and the two hindermost pairs are in distinct connection with the body of the basibranchial.

Axial Skeleton of Trunk.—The vertebræ are robust and distinctly tectospondylic, the centra being somewhat deeper than long and depressed-oval in transverse section. The constriction of the vertebral centra is slight. There are traces of slender ribs (not shown in the figure) in the region of the pelvis, but precise details as to their extent and arrangement cannot be ascertained.

Appendicular Skeleton.—In the paired fins the slender cartilaginous rays extend to the outer margin, are articulated at distant intervals, and bifurcate distally except in the most anterior portion of the pectorals. The shoulder girdle is hypothetically indicated in the figure, its remains in all known specimens being obscure; but the basal cartilages of the pectoral fins are well shown in several cases. The propterygium is considerably extended forwards and supports about 16 rays; the mesopterygium is narrow and bears 8 rays; and the metapterygium, much produced backwards, is the largest element supporting not less than 25 rays. The pectoral fins are triangular in shape and relatively large, each much exceeding in breadth the width of the pectoral arch; and their posterior apex almost reaches the pair of pelvic fins. The pelvic arch is slender, and the basipterygium is much elongated, bearing about 22 rays of which the most anterior one is considerably thickened. Of the median fins there are no certain indications, though it seems not unlikely that the little triangular expansion on the left side of the extremity of the tail in the principal specimen of the trunk,[2] will prove to be the second dorsal.

Dermal Structures.—The skin is covered with numerous very small stellate tubercles, some spinous, some indented in the centre, and those on the snout gradually passing into the single paired series of rostral teeth. The lateral borders of the head, the anterior border of the paired fins, and the sides of the tail are also strengthened by much more robust, small, smooth tubercles, closely arranged in a dense cluster.

Systematic Determination.

The Selachian thus described is shown by its vertebral axis to belong to the suborder Tectospondyli; and in the general form of

[1] Catal. Foss. Fishes, B.M., pt. i. pl. ii. fig. 4.
[2] Catal. Foss. Fishes, B.M., pt. i. pl. ii. fig. 1.

the trunk it makes some approximation to the Squatinidæ, Rhinobatidæ, Pristiophoridæ, and Pristidæ. From the first family the fish is, of course, immediately distinguished by the production of the snout; and from the second family it is likewise separated by the structure and armature of this rostrum. From the Pristiophoridæ it is distinguished by the forward production of the propterygium of the pectoral fin, which would cause the gill-clefts to open on the ventral aspect of the trunk, or at least direct them towards the ventral aspect as much as in the existing Squatinidæ; and there are also important differences in the structure of the snout and the paired fins, the latter in the Pristiophoridæ always exhibiting a great extension of skin beyond the cartilaginous rays, as in ordinary sharks. From *Pristis*, the type-genus of the Pristidæ, the fish now under discussion merely differs essentially (1) in the simple and non-implanted character of the rostral teeth, (2) in the extension of the median rostral cartilage to the end of the snout, and (3) in the relatively short and broad form of the trunk, with the pectoral fins almost reaching the pelvic pair. None of these characters, or any of the minor points to be noted in the generic diagnosis of *Sclerorhynchus*, seem to justify its being placed in a family distinct from that including *Pristis*; and the present investigation therefore confirms former suspicions as to the systematic relationships of the fish.

If so much be admitted, it is evident that *Sclerorhynchus* remains as the most generalized described form of the saw-fishes, and at the same time their earliest known representative. It is, however, difficult to understand how the curiously complex rostral teeth of the typical *Pristis* can have been evolved from an armature similar to that of *Sclerorhynchus*; and it is contrary to current belief to suppose that the much elongated trunk of *Pristis* is not a primitive inheritance from the sharks, but an indirect modification through some almost skate-like form of trunk such as that of the Lebanon fish. So far as known, *Propristis*[1] appears to be an intermediate link from the Lower Tertiary, the ordinary *Pristis*-like teeth in this genus being described as not fixed in sockets in any secondarily developed cartilage on the border of the pair of cartilages of the rostrum. Nevertheless, it must at present suffice to record *Sclerorhynchus* as occupying an undetermined position in the family, capable of definition, but awaiting the discovery of more Mesozoic and early Tertiary genera to elucidate its precise significance.

In conclusion, the following diagnoses may be appended:—

Genus *Sclerorhynchus*.

[A. S. Woodward, Catal. Foss. Fishes, B.M., pt. i. 1889, p. 76.]

Body depressed; pectoral fins relatively large, triangular, extending behind almost as far as the origin of the pelvic fins, and having the propterygium much produced forwards. Rostrum gradually expanding at the base, and supported throughout its length by the median rostral cartilage of the cranium with one pair of lateral cartilages; rostral teeth simple, loosely attached to the skin. Teeth in

[1] W. Dames, Sitzungsb. math.-phys. cl. k. preuss. Akad. Wiss. 1883, pt. i. p. 136.

jaws small, acuminate. Dorsal fins without spine. Trunk covered with minute stellate tubercles, gradually enlarging and passing on the snout into the rostral teeth; the lateral borders of the head, the anterior border of the paired fins, and the sides of the tail strengthened with dense patches of small, robust, smooth tubercles.

Sclerorhynchus atavus.

1889. *Sclerorhynchus atavus*, A. S. Woodward, Cat. Foss. Fishes, B.M., pt. i. p. 76, pl. iii. fig. 1, and Proc. Zool. Soc., p. 450, woodcut.
1889. *Squatina crassidens*, A. S. Woodward, Cat. Foss. Fishes, B.M., pt. i. p. 69, pl. ii.
1890. *Pristiophorus* (*Sclerorhynchus*) *atavus*, O. Jaekel, Zeitschr. deutsch. geol. Ges., p. 117, pl. ii. fig. 1.
1891. *Pristiophorus atavus*, O. Jaekel, Archiv. f. Naturgesch., p. 43, pl. i. fig. 1.

Type. Portion of rostrum; British Museum.

The type-species, attaining a length of about 0·85. Maximum breadth across the pectoral fins nearly equal to the length of the rostrum, which occupies about one-third of the total length of the fish. Teeth vertically ribbed, at least on the inner face. Pelvic fins more than half as long as the pectorals. Rostral teeth small and regularly arranged, compressed to a sharp edge anteriorly and posteriorly.

Formation and Locality.—Upper Cretaceous (Senonian); Sahel Alma, Mount Lebanon, Syria.

II.—On the Wenlock and Ludlow Strata of the Lake District.

By J. E. Marr, M.A., F.R.S., Sec.G.S.

THE beds above the Borrowdale volcanic group, and below the Coniston Flags, have been treated in detail in other communications, but, notwithstanding all that has been written of the higher Silurian rocks of the Lake District, something remains to be said about them. The classification adopted in this paper, reasons for which will be subsequently given, is subjoined:—

Kirkby Moor Flags	=	Upper Ludlow.
Calcareous Beds and Starfish Beds	=	Passage between Upper and Lower Ludlow.
Bannisdale Slates ... Coniston Grits ... ... Coldwell Beds	=	Lower Ludlow.
Brathay Flags	=	Wenlock.

These formations, it is well-known, are found principally in the undulating country to the south of the Coniston Limestone outcrop of the central region of the Lake District, and extend thence in an easterly direction, forming the great bulk of the Howgill Fells, and appearing finally in the neighbourhood of Settle. The Brathay Flags are found in two exposures in the neighbourhood of Dufton, on the west side of the Cross Fell inlier, indicating the probable occurrence of a synclinal occupied by these Upper Silurian strata under the newer rocks of the Eden Valley, and an outcrop of the Coniston grits is found on the extreme north of the Cross Fell area, pointing to the commencement of the Silurian rocks on the north side of the great Lake District anticline. This isolated outcrop is interesting, as the beds are here only thirty-five miles distant from

the strata of the Riccarton group, near Langholm, in Dumfriesshire, so that it is possible that we are here dealing with beds forming the southern limb of a syncline, of which the Langholm Beds form the northern limb.

The geographical distribution, and general characters of the upper groups of the Silurian strata are recorded in the Memoirs of the Geological Survey. Valuable fossil lists are given in these Memoirs, to which reference will be subsequently made, especially to the list appended to the Memoir on the district around Kendal, Tebay, and Sedbergh, edited by Mr. Strahan. As the fossils of the Brathay Flags and Coldwell Beds are there included under the head of Coniston Flags, it will be necessary for my purpose to give lists from the Brathay Flags, and Middle and Upper Coldwell Beds respectively. Several of the fossils recorded in the Survey list are not entered here, as their exact horizon remains doubtful, but the following lists give a fairly complete account of the fossils of the different subdivisions.

Brathay Flags.[1]

=Zone of *Cyrtograptus Murchisoni.*

Mr. Aveline assigns a thickness of 2,800 feet to the whole of the Coniston Flags, and of this considerably less than half appertains to this lower division, which seldom has a thickness of more than 1000 feet. The flags are very uniform in composition throughout the district; they are of a greyish-blue colour, well laminated, and frequently contain calcareous nodules. On the moorland west of Troutbeck they contain numerous indeterminable brachiopods in the lower portion, where they pass down into the Browgill shales, and these beds may be the meagre representatives of the Woolhope limestone, but the greater portion of the deposit contains fossils of few species, chiefly graptolites, which are abundant enough to show, as is well recognized, that these flags are the equivalents of the Wenlock Beds of other areas, and the same fossils are found in the Wenlock Shales of other districts.

Fossils of the Brathay Flags.

Monograptus priodon, Bronn.	Rebecca Hill; Broughton Moor; Brathay; Troutbeck; Stockdale; Cross Haw Beck; Austwick Beck.
—— *vomerinus*, Nich.	Same localities as above.
—— *cultellus*, Törnq.	Austwick Beck.
Cyrtograptus Murchisoni, Carr.	Troutbeck; Stockdale; Cross Haw Beck.
Retiolites Geinitzianus, Barr.	Brathay; Troutbeck; Stockdale; Austwick Beck.
Favosites, sp.	Stockdale.
Actinocrinus pulcher Salt.	Osmotherly Common; near Skelgill.
Aptychopsis (*cordiformis*, Jones and Woodw.) = *anatma*, Salt.?	Rebecca Hill.
Aptychopsis angulata, J. & W.?	Nanny Lane, Troutbeck.
Lingulocasis salteriana, J. & W.?	East side of Long Sleddale.
Discina?	Near Skelgill.
Cardiola interrupta, Brod.?	Leck Beck; Hebblethwaite Gill.
Orthoceras primaevum, Forbes.	Frequently.

[1] For use of this term, and those of the subdivisions of the Coldwell Beds, see Marr, Q.J.G.S. vol. xxxiv. p. 880.

The graptolites are those of the zone of *Cyrtograptus Murchisoni*. Other zones of Crytograptus may occur in the higher parts of the Brathay Flags, for the graptolites are usually found in good preservation near the base of the flags only, where the beds are less cleaved, owing to the protection afforded by the hard grits of the underlying Browgill Beds. In this lower part of the flags, graptolites may usually be found in a state of relief, though at Cross Haw Beck they are flattened. At this locality the shales at one horizon have the bedding planes crowded with *Cyrtograptus Murchisoni* in all stages of growth. Some of the forms included in the above list are probably referable to *Monograptus personatus*, Tullb., as more than one species seems to have been included in Nicholson's *vomerinus*.

Lower Coldwell Beds.

= Zone of *Monograptus Nilssoni*?

In the Lake District, the thin deposit of grit which forms the lower division of the Coldwell Beds has not hitherto yielded any fossils, but in the Ingleborough district the flags containing the graptolites of the *Cyrtograptus Murchisoni* zone are succeeded by massive grits (Ac. 2. of Prof. Hughes' sections in Geol. Mag. Dec. I. Vol. IV. p. 346). In 1887[1] I stated that the well-known Moughton Whetstones were possibly interstratified with the grits, and I find that the geological surveyors[2] record two bands of grit below these Whetstones, whilst the "Wharfe grits" of the surveyors (the same beds as those numbered Ac. 2 by Professor Hughes) immediately succeed them. It is true that the surveyors remark that the "Whetstone-bed belongs to the Upper part of the Lower Coniston Flags," but the line appears to be drawn for convenience where the grits become the dominant beds, and the fossils of the Whetstones indicate a different horizon to those of the Lower (Brathay) Flags. I have recorded *Monograptus dubius*, Suess, *M. Nilssoni*, Barr., and *M. uncinatus*, Tullb.? from these beds. Of these, the most characteristic is *M. Nilssoni*, and the zone may be named after it. The "Wharfe grits" are succeeded by beds which are certainly the equivalent of the Upper Coldwell Beds, so these grits with their Whetstone band represent Lower or Middle Coldwell Beds or both. There is no break betwixt them and the Brathay Flags, and this is important, as we shall see, when we discuss the stratigraphical horizon of the *Nilssoni*-zone.

Middle Coldwell Beds.

=Zone of *Phacops obtusicaudatus*.

The extraordinary persistence of the bedding-plane containing *Phacops obtusicaudatus* amongst these calcareous gritty flags has been elsewhere noted, and it is only necessary here to give a list of the fossils which have been discovered in this subdivision. They are:—

[1] Geol. Mag. Decade III. Vol. IV. p. 37.
[2] Geology of the Country around Ingleborough, p. 13.

Phacops obtusicaudatus, Salt.	Coldwell; Troutbeck; Helm Knot, etc.
——— *torvus*, Wyatt-Edgell, M.S. ...	East side of Troutbeck; Helm Knot.
Acidaspis, sp.	Randy Pike.
Cheirurus, sp.	Randy Pike.
Cardiola interrupta, Brod.	Troutbeck.
Orthoceras subannulare, Münst.	Coldwell? Randy Pike?
——— *angulatum*, Wahl.	Coldwell?
——— *originale*, Barr.	Coldwell?
——— *recticinctum*, Blake	Coldwell.
——— *lineatum*, His.	Coldwell.
——— ——— var. *tenuistriatum*, Blake.	Randy Pike.
——— *truncatum*, Barr.	Coldwell.
——— *imbricatum*, Wahl.	Coldwell.

The list of Cephalopods is compiled from Prof. Blake's "British Fossil Cephalopoda." Several of the above Cephalopods occur in the same beds on the north side of Helm Knot, Dent. Many other indeterminable fossils also occur, including several Brachiopods.

Upper Coldwell Beds.

=Zone of *Monograptus bohemicus* (lower part).

I pointed out in 1878 that the fossils found in the beds assigned to the Lower Coniston Grits on the East side of Lune are the same as those found in the strata included in the Upper Coniston Flags on the west side of that river, and that both immediately succeed the zone of *Phacops obtusicaudatus*, indicating that the line of demarcation between grits and flags on the east side of Lune, as drawn by the Geological Surveyors, is much lower in the succession than that which they have adopted in the central portion of the Lake District. The Brathay Flags only are included in the Coniston Flags on the eastern side; the top of these flags, as shown by the fossils, is a more natural place to draw the line, than that adopted further to the west; and it is somewhat unfortunate that the terms Coniston Flags and Coniston Grits have got into such general use, considering the vagueness of the expressions.

Since 1878 a number of other fossils have been discovered in the Windermere country, and although further search would undoubtedly furnish many more species, quite sufficient have been collected to show the correctness of the correlation of the Upper Coldwell Beds of the Windermere country with the gritty flags of the S.W. side of Helm Knot, Casterton and Middleton Fells, Horton-in-Ribblesdale, etc. These beds, in some cases certainly, attain a thickness of about 2000 feet, though elsewhere a smaller thickness is at present measurable.

Fossils of the Upper Coldwell Beds.

Cliona prisca, M'Coy.	Helm Knot; Casterton Fell.
†*Monograptus colonus*, Barr.	Broughton Moor; Windermere, Sedbergh, and Ribblesdale districts.
†——— *Rœmeri*, Barr.	Windermere, Sedbergh, and Ribblesdale districts.
†——— *bohemicus*, Barr.	Windermere, Sedbergh, and Ribblesdale districts.
‡*Spirorbis Lewisii*, Sow.	Casterton Fell; Helmside.
†*Actinocrinus? pulcher*, Salt.	Casterton Fell; Cautley; Horton; Troutbeck.

Protaster sp.	Casterton Fell.
†*Ceratiocaris Murchisoni*, Agaz.	Casterton Fell; Helm Knot; Troutbeck; South of Coldwell.
‡——— *robusta*, Salt.	Casterton Fell; High Hollins; Helm
‡——— *tyrannus*, Salt....	Troutbeck. [Knot.
§*Encrinurus punctatus*, Brünn.	Middleton Fell.
†*Homalonotus Knightii*, König.	Middleton Fell.
**Acidaspis Hughesii*, Salt., M.S.	Casterton Low Fell; Helm Knot; Galegarth; Ravenstonedale.
†*Phacops Stokesii*, M. Edw.	Troutbeck; Outrake, Ulverston.
*——— *torvus*, Wyatt-Edgell, M.S. ...	Troutbeck.
——— *caudatus*, Brongn. var.	Troutbeck.
Orthis Lewisii, Dav., var. *Hughesii*, Dav.	Helm Knot.
‡*Dayia navicula*, Sow.	Middleton Fell.
†*Rhynchonella nucula*, Sow.	Middleton Fell.
Orthis parva, var. *avellana*	Horton.
†*Discina Forbesii*, Dav.	Middleton Fell.
†*Cardiola interrupta*, Brod.	Windermere; Sedbergh; and Settle
‡*Pterinea subfalcata*, Conr.	Howgill Fells. [districts.
†——— *tenuistrita*, M'Coy	Casterton and Middleton Fells; High Hollins; Helm Knot.
†——— *Sowerbyi*, M'Coy	Helm Knot.
Ctenodonta sp.	Helm Knot.
‡*Tentaculites tenuis*, Sow.	Cautley.
†*Orthoceras primævum*, Forbes	Horton; Helm Knot; Troutbeck.
‡——— *dimidiatum*, Sow.	Helm Knot.
†——— *subundulatum*, Portl.	Horton; Howgill Fells; Hawkshead.
†——— *ludense*, Sow.	Helm Knot.
‡——— *tracheale*, Sow....	Howgill Fells.
†*Trochoceras giganteum*, Sow.	Horton.

* Not recorded outside the district.
† Recorded elsewhere from Ludlow and Wenlock Beds.
‡ Recorded elsewhere from Ludlow only.
§ Recorded elsewhere from Wenlock only.

NOTE.—No account is taken of occurrences in the Denbighshire Grits and Flags.

CONISTON GRITS.

=Zone of *Monograptus bohemicus* (upper part).

The main mass of these grits, estimated by Mr. Aveline to have a thickness of 4000 feet, is unfossiliferous. Two interesting fossil horizons are found, however, viz., the Winder Grit, described by Prof. Hughes in the Geological Survey Memoir on the district around Kendal, Sedbergh, and Tebay (see first edition, published in 1872), with a set of fossils enumerated in the two editions of that Memoir, which it is not necessary to print here; and the "sheerbate flags" exposed in Pennington's Quarry, on the east side of Troutbeck, which contain the three *Monograpti* enumerated as occurring in the Upper Coldwell Beds, *colonus, bohemicus, Rœmeri,* along with *Cardiola interrupta* and *Orthoceras primævum.*

BANNISDALE SLATES.

=Zone of *Monograptus leintwardinensis.*

A considerable number of fossils have been found scattered through the Bannisdale slates (whose thickness is given by Mr. Aveline as 5,200 feet). They are recorded from various localities, such as Tebay Gill, Crook of Lune, Bowness, etc., and a list of these fossils will be found in the Survey Memoir previously alluded to. Fossils,

though rare, can generally be found in sections where the cleavage has not obliterated the bedding planes as planes of division. Some years ago I noticed *Monograpti* on a slab from Reston, near Ings, preserved in the Kendal Museum, which appeared to me to be *M. leintwardinensis*, and though I was unsuccessful in finding these fossils *in situ* at that locality, I last summer discovered that species of *Monograptus* in decomposed gritty shales not far above the top of the Coniston Grits in Tebay Gill, associated with *Monograptus colonus*, Barr., *M. Salweyi*, Hopk., a species of *Ceratiocaris*, and several lamellibranchs. On my return to Cambridge, I found other specimens of *leintwardinensis*, in a drawer containing fossils from the passage beds between the Bannisdale Slates and Kirkby Moor Flags at Underbarrow, and a specimen from the Crook of Lune, which seems to belong to the same species. *M. leintwardinensis*, then, appears to range through the Bannisdale Slates, and I have not met with it in higher or lower beds.

The lower portions of the passage beds between the Bannisdale Slates and Kirkby Moor Flags are well-known from the occurrence of Starfish in them, whence they are frequently spoken of as the Starfish beds; it may be noted that Starfish also occur at a lower horizon in the Bannisdale Slates. The Starfish beds have yielded a rich fauna at Underbarrow and elsewhere, and their fossils are recorded in Salter's Catalogue of Cambrian and Silurian fossils as well as in the Survey Memoir. Mr. Aveline compares the beds above them with the Aymestry Limestone, and this correlation has been generally accepted. These upper beds are calcareous and contain *Dayia navicula* in abundance.

Kirkby Moor Flags.

These well-known and richly fossiliferous strata are by general consent referred to the Upper Ludlow. A large suite of fossils from the immediate vicinity of Kendal and Kirkby Moor is preserved in the Kendal Museum, and another in the Woodwardian Museum, and these are recorded in Salter's Catalogue and that appended to the Survey Memoir. Numerous fossils are embedded also in the less known flags found in the synclinal running from Staveley to Tebay, and though many of these are of species occurring in the outcrops of the main mass it would well repay local observers to collect fossils from the flags of this syncline, especially in those places where they pass down into the underlying Bannisdale Slates. It is quite unnecessary to give a full list of the fossils of the Kirkby Moor Flags.

Conclusions.

It has been stated that the Brathay Flags are generally recognized as the equivalents of the Wenlock strata, whilst the Kirkby Moor Flags are equally generally accepted as of Upper Ludlow age. The upper portion only of the Bannisdale Slates is admitted to be Lower Ludlow by the Geological Surveyors, whilst the lower part of the Bannisdales, the whole of the Coniston Grits, and the Coldwell Beds are referred to the Wenlock. If this be so, we should have some-

thing like 10,000 feet of Wenlock strata in the district, and only two or three thousand of Lower Ludlow. I hope to show, however, that the Lower Ludlow comprises all the strata between the top of the Brathay Flags and the calcareous deposit referred to the Aymestry limestone at the top of the Bannisdale Slates; in other words, that the three divisions of the Coldwell Beds, the whole of the Coniston grits, and the whole of the Bannisdale slates excepting the calcareous summit (=Aymestry limestone) are of Lower Ludlow age. My reasons are as follows:—(1) At the end of the period of deposition of the deep-water Brathay Flags which are of uniform lithological character from top to bottom, and of very fine material, there was a marked change producing much shallower water deposits which are comparable in lithological characters not with the Wenlock but with the Lower Ludlow shales of other areas. It is possible that the Lower and Middle Coldwell Beds do represent the Wenlock Limestone of other areas, but I think not, and believe that the Wenlock Limestone is absent, and that these Lower and Middle Coldwell Beds are Ludlow.

(2) On account of the nature of the graptolites found in the Moughton whetstones, which immediately succeed the Brathay Flags of Austwick. The graptolites are *Monograptus dubius* and *M. Nilssoni*. These two species are found in the 'Cardiolaskiffer' of Scania, and *Nilssoni* is limited to the base of the 'Cardiolaskiffer.'[1] These Cardiola Beds are correlated by Tullberg with our Lower Ludlow.[2] Again, in Lapworth's paper on the geological distribution of the Rhabdophora, *M. Nilssoni*, is recorded from Lower Ludlow rocks only in the table showing the distribution of the various species of graptolite, and he speaks of the zone of *M. Nilssoni* as lying between the Wenlock and Aymestry limestones, and forming the Lower Ludlow shales of Murchison.

(3) The fossils of the Middle Coldwell Beds give little or no indication of age, and might equally well be Wenlock or Ludlow; but this is not the case with the Upper Coldwell Beds. These beds have the fauna of the Cardiolaskiffer of Sweden (which, as already stated, is correlated by Tullberg with the Lower Ludlow). But the fossils of the Upper Coldwell Beds themselves strongly support their Ludlow affinities. I have indicated in the list those which are confined to the Ludlow, those which occur in the Wenlock also, and that (I can find but one, and the identification of that is doubtful) which has been elsewhere found in the Wenlock only. I would not lay much stress on this, except as showing that the probabilities are quite as much in favour of the beds being Ludlow as of their being Wenlock; but when we deal with the graptolites we have more certain evidence, for though the three species found in the Upper Coldwell Beds have been recorded from the higher Wenlock strata, they only are found in the abundance in which they lie in some of the Upper Coldwell Beds, in Lower Ludlow strata at home and abroad. Furthermore, some of the fossils limited to the Lake District pass up into the Coniston Grits and even into the Bannisdale

[1] *Cf.* Tullberg, Skånes graptoliter. Part I. p. 14.
[2] *Cf.* Aft. ur. geol. Fören. i. Stockholm Fordhandl. 1880, No. 59, Bd. V. No. 3.

Slates; but they are not found in the Brathay Flags, and the same is true of a great portion of the other fossils, so that if the list of fossils from Bannisdale Slates, Coniston Grits, and Upper Coldwell Beds be examined, a large number will be found common to the three.

(4) The Coniston Grit fossils have a decided Lower Ludlow facies. So much is this the case that Prof. Hughes remarks of the fauna of the Winder grit "The prevalence of *Rhynchonellæ*, especially *R. navicula*, of *Chonetes lata*, of that round rather than elongated variety of *Orthis elegantula*, known as *O. lunata* or *orbicularis*, and other fossils, would, in Wales, lead one to suspect that we were somewhere about the passage beds from Upper to Lower Ludlow."[1] It is true that an explanation is offered in the Survey Memoir to account for an apparent Ludlow fauna in Wenlock strata, but if all these strata be, as I am attempting to show, Ludlow, no such explanation is needed.

(5) *Monograptus leintwardinensis*, occurring in the Bannisdale Slates, was determined as a Lower Ludlow form by Mr. Hopkinson in 1873.[2]

An interesting point brought out by an examination of the Lower Ludlow graptolite-bearing deposits of the North of England is the great thickness of some of the graptolitic zones of these rapidly accumulated shallow-water deposits, forming a marked contrast to the thinness of the graptolitic zones of Llandovery age in the same area. Thus we find the zone of *Monograptus bohemicus* comprising a group of strata having a thickness of about 5000 feet, whilst a similar thickness is assigned to the strata of the zone of *M. leintwardinensis*. A list of the zones of the Llandovery-Ludlow rocks of the area of the Lakes is appended, with the approximate thickness of the beds of each zone.

Equivalents in Silurian Region.	Zone of	Local Names.	Ft.	in.
Lower Ludlow.	*Monograptus leintwardinensis*	Bannisdale Slates	5000	0
	——— *bohemicus*	Coniston Grits U. Coldwell Beds Middle	5000	0
	——— *Nilssoni*	Lower	1000	0
Wenlock.	*Cyrtograptus Murchisoni*	Brathay Flags ...	1000	0
Tarannon.	——— *Grayae band*	... ...	to 22	0
	Monograptus crispus	Browgill Beds ...		
	——— *turriculatus*	... ...	to 60	0
Llandovery.	*Rastrites maximus*	... ...	25	0
	Monograptus spinigerus	... ...	3	0
	——— *clingani band*	... ...	3	0
	——— *convolutus*	Skelgill Beds ...	7	6
	——— *argenteus*	... ...	0	8
	——— *fimbriatus*	... ...	7	6
	Dimorphograptus confertus ...	... ...	to 25	0
	Diplograptus acuminatus	... ...	2	6

[1] Survey Memoir, Geology of the Country about Kendal, Sedbergh, etc., p. 16.
[2] Geol. Mag. Decade I. Vol. X. p. 519.

III.—On the Occurrence of *Chonetes Pratti*, Davidson, in the Carboniferous Rocks of Western Australia.

By R. Bullen Newton, F.G.S.,
of the British Museum (Natural History).

[Read at the British Association, Edinburgh Meeting, 1892.]

(PLATE XIV.)

THE Government of Western Australia, through their Geologist, Harry Page Woodward, Esq., F.G.S., has recently presented to the British Museum an important series of Palæozoic invertebrate fossils which have been collected from various localities during the progress of the geological survey of that colony.

Since their arrival in this country the majority of the specimens have been figured and described in the Geological Magazine for 1890, by Mr. A. H. Foord, Dr. G. J. Hinde, and Prof. H. A. Nicholson.

Among the Brachiopoda from the Irwin River District are three well-preserved valves of a *Chonetes*, consisting of two dorsals and one ventral, which have not yet received identification from the authors referred to, as they came in a second consignment, and after the description of the first series had been published. These valves belong to one species, though to different specimens; the ventral being deeply convex, possessing a prominent central depression, and internally showing well-defined muscular scars, whilst the dorsals retain in singular clearness the reniform vascular impressions in addition to the usual muscular markings.

Desirous of being able to refer these specimens to some described species, it was necessary to consult the unique collection of Brachiopoda formed by the late Dr. Thomas Davidson, now contained in the British Museum, and which at the present time is undergoing a detailed arrangement. There my attention was drawn to the figured example of a form called *Chonetes Pratti*, which Davidson had described as long ago as 1859, in the "Geologist," and which apparently has never since been referred to either by the author himself or by any other specialist of the Brachiopoda. This type consists of a dorsal and ventral valve belonging to the same animal, and its comparison with the Western Australian specimens has resulted in the fact that in every essential character, both mineralogical and structural, it is identically the same, a point of much interest when it is remembered that the Davidson specimen up to this time has been without locality or horizon. The author's description of this species is included in the Explanation of the Plates attached to his essay "On the Families Strophomenidæ and Productidæ," published in the "Geologist" for 1859 (pl. 4, figs. 9–12, p. 116), and is here reproduced, the words in square brackets being used to connect the meaning:—

Chonetes Pratti.—This beautiful specimen (from the collection of Mr. Pratt) is here given as an illustration of the genus, on account of the admirable preservation of its valves. The specimen is silicified[1] and the valves can be as easily separated

[1] This statement requires correction, as on submitting the figured examples to the test of Hydrochloric acid their structure is found to be calcareous. My colleague, Mr. Thomas Davies, F.G.S., has also examined the fractured edge of one of the valves, and he identifies the cleavage planes as belonging to Carbonate of Lime.

as in those of a recent species. Its locality is unfortunately unknown. The ventral valve is very deep, with a longitudinal depression along its middle; the dorsal valve is almost flat, with a small elevation towards the front; both valves are covered with minute striæ. The interior of the ventral valve [shows the] *occlusor* and *divaricator* muscular impressions. The cardinal spines and their tubuliform orifices are here clearly exhibited. The interior of the dorsal valve [shows the] cardinal process, [the] anterior and posterior occlusor muscular impressions, [the] ovarian spaces (?), [and the] reniform impressions. The granular prominences are here beautifully exhibited.

To these characters might be added:

(1) That the external surface of both valves, besides being ornamented with very fine radiating striæ, possess subimbricating concentric lines of growth; (2) that the extent of the cardinal line represents the minimum width of the shell; (3) that the granular asperites on the interiors of the valves are disposed in lines as they reach the margins, and they are elongate and perforate, presenting the appearance of short tubular spines; (4) that the external surface of the ventral valve exhibits a number of small orifices placed at irregular distances, which might represent the basal attachments of short spines, a character known to exist in *Chonetes papilionacea*, *C. Hardrensis*, etc.; and that between the striæ or ribs there occur numerous minute perforations.

The dimensions of the figured ventral valve [not given by Davidson] are as follows:—

Maximum breadth	=27 mm.
Minimum breadth (at cardinal margin)	=24 ,,
Maximum length	=19 ,,
Minimum length	=17 ,,
Depth of convexity	= 8 ,,

Two of the valves from Western Australia represent somewhat larger specimens with the following measurements:—

Ventral Valve.

Maximum breadth	=29 mm.
Minimum breadth	=25 ,,
Maximum length	=21 ,,
Minimum length	=20 ,,
Depth of convexity	= 9 ,,

Dorsal Valve of another Specimen.

Maximum breadth	=30 mm.
Maximum length...	=20 ,,

The deep median depression appears to be a somewhat rare character in the true *Chonetes* although it is exemplified in some species such as the *C. mucronata*[1] of F. B. Meek and T. V. Hayden. This American form, however, differs in other respects from *C. Pratti* in being widest at the cardinal margin, in possessing a greater number of cardinal spines, and in having its ventral valve of a lesser convexity.

The general collection of Brachiopoda in the British Museum contains a single dorsal valve of *C. Pratti*, labelled "Russia" by Professor Morris, in whose collection it formerly was, which so exactly coincides with the other valves here recorded that I am

[1] Description of some new species of Carboniferous Fossils from the Valley of Kansas River, Proc. Acad. Nat. Sci. Philadelphia, 1858, p. 262 (not figured).

strongly inclined to think that a mistake was made when he attached this locality to his specimen, more especially as on reference to our Russian Brachiopoda there is no form with which to compare it either structurally or lithologically, nor have I succeeded in tracing anything in literature with which to gain any knowledge as to its probable locality. There is every reason to believe that this supposed Russian valve came also from Australia, and most probably, as suggested to me by Dr. H. Woodward, F.R.S., was sent to Prof. Morris as a part of the "Strzelecki" collection, the fossils of which he described in 1845.[1]

The foregoing remarks may therefore lead to the following conclusions:—(1) That the valves discovered by Mr. H. P. Woodward can be referred, without a doubt, to *Chonetes Pratti* of Davidson. (2) That the Davidson type, *hitherto unlocalized*, was most likely obtained from Australia. (3) That the valve labelled "Russia" came, in all probability, from the same country.

In conclusion, it may be of interest to quote the other Carboniferous fossils identified by Messrs. Foord[2] and Hinde[3] from this same portion of Western Australia, viz. the Irwin River District, which has now produced the *Chonetes Pratti* of Davidson. These species are as follows:—

Productus tenuistriatus, Verneuil; *P. undatus*, Defrance; *P. subquadratus*, Morris; *Spirifera Musakheylensis*, Davidson, var. *Australis*, A. H. Foord; *Syringothyris exsuperans*, Koninck; *Reticularia lineata*, Martin, sp.; *R. crebristria*, Morris, sp.; *Orthotetes crenistria*, Phillips, sp.; *Pachydomus carinatus*, Morris; *Bellerophon decussatus*? Fleming; *Orthoceras*, sp.; *Discites*, sp.; *Pleurophyllum Australe*, Hinde; *P. sulcatum*, Hinde.

EXPLANATION OF PLATE XIV.

Figs. 1–5.—Reproduction of the original figures of *Chonetes Pratti*, taken from the "Geologist," of 1859, pl. iv. figs. 9–12. 1, 2.—Ventral and dorsal view of specimen. Nat. size. 3.—Enlarged portion of valves, showing pseudo-deltidum and (J) cardinal process. 4.—Interior of ventral valve, enlarged, showing (A) the occlusor or adductor and (R) the divaricator or cardinal muscular impressions. The cardinal spines and orifices are also seen. 5.—Interior of dorsal valve, enlarged, showing (J) the cardinal process; (A, A′) anterior and posterior occlusor muscular impressions; (O) ovarian spaces?; (X) the reniform impressions. The dotted surface represents the granular ornamentation.

,, 6–10.—The three valves collected by Mr. H. P. Woodward in Western Australia, natural size. 6, 7, interior and exterior of ventral valve. 6*a*, magnified portion of fig. 6, showing orifices on the ribs between which are the minute perforations. 8, 9, 10, interior and exterior of dorsal valves. 8*a*, magnified portion of fig. 8 showing the arrangement and perforated condition of the spinous asperities.

,, 11, 12.—Interior and exterior of dorsal valve of the specimen said to come from Russia, but which in all probability was originally part of the "Strzelecki" Collection from Australia.

[All the six specimens figured are in the British Museum (Natural History) Cromwell Road, South Kensington.]

[1] Physical Description of New South Wales and Van Dieman's Land, by P. E. de Strzelecki. [2] Geol. Mag. 1890, Pl. VII. p. 151–155.

[3] Geol. Mag. 1890, Pl. VIIIa. p. 196.

IV.—Notes on the Process of Schist-making in the Malvern Hills.

By Charles Callaway, D.Sc., M.A., F.G.S.

In the October Number of this Magazine, a paper by the Rev. A. Irving, D.Sc., calls for some comment. The subject, "The Malvern Crystallines," is one which has engaged my close attention during the last seven years, and two expositions of my views have appeared in the Quarterly Journal of the Geological Society.[1] I am glad to find that Dr. Irving accepts my main conclusion—that the Malvern gneisses and schists are of igneous origin; but there are some important details in which he has formed a different opinion. It will not be necessary for me to discuss these differences with any fulness, since my third and final paper, which is nearly ready, treats of some of his more material objections to my views.

One of the most important points of difference is the *origin of the granite-veins*. I hold that they are injected into the diorites, and therefore posterior in age; Dr. Irving regards them as segregatory and contemporaneous. I notice, with some surprise, that Dr. Irving quotes the late Prof. John Phillips in support of his theory. The words of the Oxford Professor, as recorded in the "Geology of Oxford and Valley of the Thames," appear to me to contradict his claim. Writing on the granites, diorites, and other crystalline rocks of Malvern, Phillips says (p. 62):—"Segregation from a fused mass is often regarded as the cause of these irregular mixtures; in several cases, however, the posteriority of felspathic and granitic veins to the masses which they traverse is quite certain. . . ."

Dr. Irving contends for the segregatory and contemporaneous origin of the granite-veins on the following grounds:

(1) Upon the way in which the diorite and the granite "graduate into one another;" and he alleges a case at West Malvern of a "gradation from diorite through a biotite or hornblendic-granite to a very coarse pegmatite."

My experience upon this point lends no support whatever to this alleged graduating. There are few outcrops in the Malvern range which I have not examined, and I have never succeeded in finding a passage between granite and diorite. On the other hand, I have observed hundreds of contacts between those two rocks, in which they were seen to be sharply distinguished from each other, and I have examined scores of these contacts under the microscope with the same result. The supposed "gradation" at West Malvern is probably a case of the action of granite on diorite in contact, of which there are plenty of examples in that locality.

(2) "Upon the way in which the felspathic and the quartzo-felspathic veins ramify in all directions through the diorite."

This might sometimes be the case if the granite was ejected from below. The molten rock would pass along lines of least resistance, which would sometimes be horizontal or even trend obliquely downwards. As a matter of fact, however, a large proportion of the veins

[1] August, 1887, p. 525; August, 1889, p. 475.

are seen to rise from below, thinning out upwards and often forking (see fig. 2, p. 482, Quart. Journ. Geol. Soc. August, 1889). For one vein that runs horizontally, there are perhaps a hundred that are almost vertical.

(3) "Upon the fact that very often the hornblendic rock is observed to be more completely basic in immediate contiguity with the felspathic veins."

It is true that sometimes there is an aggregation of hornblende or biotite forming a rim to the diorite at the junction with a granite-vein, as I pointed out in 1889 (*loc. cit.* p. 494); but I hold this to be the effect of the injection of the granite, by which a process of mineral aggregation and enlargement is originated, as had been noticed in other localities by Allport, Bonney, and others. Dr. Irving's theory of these basic rims does not explain why, when the hornblende (or biotite) is segregated from the felspar, it should leave on one side of it a band of plagioclase (mainly), and on the other a band which is chiefly orthoclase and quartz. The segregation of hornblende from felspar has, indeed, often taken place in the Malvern diorites, but, so far as I have seen, the felspar remains mainly diorite-felspar, viz. plagioclase.

(4) "Upon the very significant fact, that the quartzo-felspathic veins, even when less than an inch in thickness, have a coarsely-grained structure, this being so manifest as to make it impossible to believe that they crystallized in contact with a colder rock after injection into it."

Dr. Irving is justified in attaching importance to this argument. If it stood alone, it would have great weight. But the facts making in the opposite direction are so strong (*loc. cit.* pp. 494, 495) that I think it will not do to attach much value to a fact which may be susceptible of another interpretation. It is likely enough that when the veins were injected, the diorite was at nearly as high a temperature as the granite, so that the veins may have cooled down nearly as slowly as the large masses of granite with which they were in connection. For my part, I find it incredible that masses of potash-granite, hundreds of yards in diameter, should have segregated out of the diorite, that the segregated matter should be as coarsely crystalline in fine-grained diorite as in the granitoid variety, and that veins of segregation should produce the same contact-effects as veins of injection.

A second important detail is *whether schistosity was produced before or after consolidation.* Speaking generally, Dr. Irving says, "before." Speaking generally, I say, "after." The reasons for my view are given in part in my second paper, and will be continued in my next. I confine myself in this article to a brief reference to the "cakes" of quartz or quartz-felspar which occur in some of the more felspathic masses. Dr. Irving supposes that this flattening out into "cakes" took place when the quartz was in a colloid state. I select this case because it may seem to be a strong point in his favour. There is, however, pretty clear evidence that these "cakes" are merely very large "eyes," such as occur on a smaller scale in augen-gneiss.

The rock surrounding them, wherever I have seen them, is sheared into a well-foliated gneiss, with well-marked granulitic structure. Each "cake" forms a nucleus around which the gneissic folia are arranged concentrically, and would appear to be merely a tough mass which has succeeded in resisting the shearing action of the earth-mill. The granulitic structure would of itself suggest dynamic deformation subsequent to consolidation. The sheared rock was originally binary granite of very coarse grain, into which it often passes by imperceptible gradations, and the "eyes" can be identified as the same kind of granite, though they have often become more highly siliceous.

Dr. Irving does not appear to dispute that the *production of biotite in the diorite* is sometimes the result of contact alteration; but he denies that such is always the case at Malvern, and he instances the rock in the large quarry at the north-west corner of Swinyard's Hill. He states that the "kersantite" shows "no progressive alteration" as it approaches the "basic dykes." I should be very much surprised if it did. My induction was that usually black mica was developed in diorite at the contact with the granite-veins. It is true that no granite is visible in this quarry; but it is also true that one of the largest masses of granite (pegmatite) in the Malvern Hills crops out at a little distance to the east, where it forms the ridge of the hill for several hundred yards.

The *sericite-schists* of the south-western spur of the Raggedstone have attracted the attention of Dr. Irving. He thinks they form "a fragment of the lithosphere belonging to a much later stage of development than the rest of the Malvern chain," and he "failed in his attempt to trace a gradual transition from them into the gneissose rocks adjoining these schists." These schists are of extreme interest, and will be fully discussed in my third paper. In this place I may say that I *have* traced a "gradual transition" between them and the coarse-grey diorite, and I am in a position to prove by means of a series of about forty microscopic slides, cut from the diorite, the schist, and the intervening rock, that this highly acidic schist has been formed out of the diorite by a process of crushing and shearing, acting subsequently to the intrusion of the granite-veins and to the solidification of the mixed rocks.

On the *mica-schist* (formed from felsite) of the south-eastern spur of the Raggedstone, I have merely a word to say. Dr. Irving thinks I ought not to apply the term "schist" to this rock; but he does not deny that "cleavage-foliation" is to be seen in it. If there is true "cleavage-foliation" in the rock, surely it is entitled to be called a "schist" in the strictest sense of the word, if the usage of British geologists, from Jukes onward, is to go for anything. But Dr. Irving appears to use the term "cleavage-foliation" in a peculiar manner, since he compares this Raggedstone schist with certain "laminated sandstones, on the lamination surfaces of which a similar deposit of secondary mica has taken place." I cannot for a moment admit that such a comparison is justified by the facts. If Dr. Irving will turn to my first paper (1887, p. 531), he will see that, while

some of the passage rock is merely a sheared felsite with secondary mica deposited on the shear-surfaces, the central part of the shear-zone consists of true foliated schist.

Dr. Irving seems to employ the term "*shear-plane*" in a sense entirely different from my definition and description (1889, pp. 476, 477). My shear-planes *do* display a "rough parallelism," and they *do not* "cut through the rock-mass at all angles to the quarry face." Dr. Irving says that his "shear-planes" "are often conspicuously slickensided," and from his description of them, I should be disposed to think that they are merely the effects of crushing and sliding taking place long after the schist-making process was completed. This sort of thing is well-known and well-understood, and has no bearing upon the facts and theories set forth in my papers.

It should be clearly understood that it is impossible to see into the mechanism of the schist-making process in the Malvern rocks without the study of large numbers of microscopic slides. As Dr. Irving has not given us any details of microscopic structure, we are left in the dark as to the evidence on which he bases his conclusions.

V.—On Yorkshire Thecidea.

By John Francis Walker, M.A., F.G.S., etc.

I HAVE obtained a considerable number of specimens of *Thecidium ornatum*, Moore, from the Coral Rag, in the bed containing *Phasianella* (*Pseudomelania*) *striata*; *Pseudodiadema versipora*, *Hemicidaris intermedia*, etc., from a quarry between Ayton and Scarborough. My friend, the late Mr. Charles Moore, F.G.S., gave me some specimens of this Brachiopod from the Coral Rag of Lyneham, Wiltshire, with which the Yorkshire *Thecidium* perfectly agrees in form. This shell, especially the dorsal valve, is plentiful at Ayton, but it is troublesome to find on account of its small size; it is best obtained by washing the marl; occasionally it is found attached to Ostrea. In my paper "On the Yorkshire Brachiopoda," York. Phil. Society Report, 1888, I remarked that a species of *Thecidium* occurs at Suffield, near Scarborough, in the Lower coral rag, generally attached to specimens of *Zeilleria Hudlestoni*. I have lately obtained by washing the sand some perfect shells, and consider that they are probably *Thecidea Moreana*, Buvignier.

VI.—Woodwardian Museum Notes.

By F. R. Cowper Reed.

AMONGST the Carboniferous Crinoidea in this Museum an abnormal form of *Platycrinus pileatus*, Goldf., from the Carboniferous Limestone of Bolland was recently discovered by me whilst cataloguing the collection. This specimen has only four arms and the calyx has suffered a corresponding diminution in the number of its plates. The cup is conical, and when viewed from the base roughly quadrangular: it expands somewhat rapidly so that its greatest diameter is only slightly less than its height. The three

basals are unequal in size, and form a rude, quadrilateral, cup-shaped figure which extends a little more than one-third up the sides of the calyx. The point of attachment of the stem is small.

The four radials are large, with the usual expansion above to enable them to accommodate themselves to the form of the calyx, their mean length and breadth being nearly equal. The excavation for the arm occupies more than one-third the breadth, and its depth bears about the same proportion to the length of the plate.

The inter-radials occupy the spaces exactly between the arms, and apparently have two shorter lower sides and two longer upper sides which therefore meet at a more acute angle.

The vault is flattened, quadrate, and composed of a few large polygonal plates each bearing a prominent central tubercle, which is especially large at the base of each arm.

In this specimen the arms are wanting, being broken off close to the calyx.

It has been thought that it might be of use to place on record the occurrence of this abnormal form in view of the discussions still going on in regard to variations in recent types.

VII.—Notes on Russian Geology.[1]

By W. F. Hume, B.Sc., A.R.S.M., F.G.S.;
Demonstrator in Geology, Royal College of Science.

II. The Loess: Its Distribution and Character in S. Russia.

COVERING a vast extent of the southern portion of Russia in Europe, occurs the sandy clay which is commonly known as Loess, whose origin has given rise to the most varied and conflicting opinions. In the course of a visit to the above country, this deposit struck the writer as well worthy of further study, whilst its connection with the Black Earth invited closer inspection. Its distribution and general characters, as regards the greater part of Western and Central Europe, have been dealt with in a most masterly manner by Baron von Richthofen in his "China," chap. v.; but at the Russian frontier his description ceases almost abruptly, and he merely mentions that the Dniester and its tributaries appear to have cut their channels through the Loess.

The statements about to be made apply especially to this deposit as it occurs in the Governments of Podolia, Kieff, Kharkoff, Kursk, Ekaterinoslav, Poltava, Tchernigov, and the Don Cossack country, districts which more or less came under my immediate notice. (For map of region see Geol. Mag. September, 1892, p. 387.) As elsewhere, so here it occupies the highest position in the geological sequence, lying unconformably on all the principal formations. To the W. of the Dnieper it hides beneath itself the broken and contorted gneisses and granites of the Archæan axis, in S. Ekaterinoslav and the Don Cossack country it covers the shales and sandstones of the Carboniferous, whilst in the more central governments of Kursk, Kharkoff, and Tchernigov it overlies the Cretaceous and the whole

[1] For No. I., Cretaceous, see Geol. Mag. September, 1892.

Tertiary series. Also along a certain definite line running to the north of these governments, it rests upon the Boulder-clays and sands of the Glacial period.

Owing to the numerous studies to which this superficial formation has given rise, its special characteristics have been clearly defined, and have generally proved applicable to Loess in every region of the globe where it is known to occur. These may be briefly summarized as follows:—

Similarity in the size of the component grains.

Want of stratification.

Capillary texture and perpendicular cleavage.

Large amount of carbonate of lime present, either as nodules, as a cementing material, or coating the inner cavities of decayed roots.

Presence of land-shells and Mammalian remains.

The Russian Loess may be defined as a yellow-brown sandy clay, very often rich in grains of quartz and flakes of mica, extremely compact when an attempt is made to dislodge it in large pieces; yet so loosely aggregated as to flow through the fingers on the slightest friction. There are, however, secondary additions of very great importance, amongst which humus and carbonate of lime hold the most prominent place. In pursuing the subject, I propose to take the facts in the order in which I have observed them, reserving a discussion of the theoretical conceptions arising therefrom to the end of the paper.

The town of Kieff is not only remarkable as the centre of the Greek Church, the spiritual metropolis to which the heart (and generally the steps) of every true orthodox Russian turns during some period of his lifetime, but is also of a peculiar interest from a geological standpoint, owing to the magnificent sections which are here exposed to view. I had the additional advantage of being conducted to the principal points of interest by Prof. Armachevsky, of Kieff University, who, with the kindness so often to be met with in Russia, took a large amount of trouble in introducing the various geological features to be seen in the neighbourhood. It may be briefly stated that the exposures display a complete view of the West Russian Tertiary and Quarternary strata, and serve as a good index to the beds of similar character which cover the greater part of Central South Russia.

The town itself is situated on high ground, 300 feet above the river Dnieper, the frontage to the river being formed by a steep cliff like escarpment. The summit is covered by 70 feet of Loess, which itself overlies a considerable thickness of glacial clays filled with boulders derived from Scandinavia and Finland. This evidence of the relative age of the two deposits is of some interest as bearing upon the origin of the former. A similar relationship has been frequently observed in other countries; Fallou noticed it in Saxony, while Foetterle (Verhand K. K. Reichsanstalt, 1889, pp. 102–104), Stur and Wolff have remarked the same in Galicia. Whilst in general the quartz-grains enclosed in the Loess are similar in size, exceptions are not unfrequent. Thus at Kieff larger rounded grains occur,

which may be over one-fourth of an inch in diameter, far exceeding the general average of their fellows.

In a brickyard to the S. of the town a further point of interest is displayed, a point indeed to which Prof. Armachevsky attaches great importance. The higher part of the quarry is formed of a very fine white sand, supposed to be of Miocene age. Its surface had evidently undergone considerable denudation before the superjacent deposits were laid down upon it. These consist of a thick layer of Loess, which is *markedly stratified* at the base, the stratification lines agreeing with the slope of the denuded sand-surface beneath. Prof. Armachevsky regards this as a strong proof of the action of running water, and has pointed out numerous similar cases in his work on the Tchernigov Government, as at pp. 12, 14. Indeed, in almost every exposure mentioned by him in the N. E. of that government the same stratified condition of the base of the Loess is noted, pointing to a different process of deposition during the earlier portion of the period in which it was forming.

At the back of the town, this sandy clay is undergoing rapid denudation, giving rise to very broken ground, the many-branched ravines, which are one of its peculiarities, being clearly marked. This feature, though already noticeable in the upper parts of the Dnieper basin, attains an enormous development on the Steppe plateaux which lie between the town of Ekaterinoslav and the Krivoi Rog hæmatite mines.

In these districts deep gorges are formed under the influence of atmospheric waters, percolating through the extremely porous soil. Possibly owing to the *capillary* texture produced in it by the roots of plants penetrating perpendicularly through it, the Loess tends to split in a vertical manner. This occurs during the hot summer period, then, when the rains come on, the water finds its way down the cracks, and large pieces are flaked off, leaving almost perpendicular walls. These precipitous ravines, piercing far into the table-lands, give to the scenery (paradoxical though it may appear to say so) an almost mountainous character, the general effect being enhanced by the vastness of the setting. To so alarming an extent has this action spread, that the railway joining Ekaterinoslav and the above mines is now, in many places, only a few yards from the edge of the abyss, and special precautions have to be taken to divert the drainage from points which are in most imminent peril. Sometimes the wearing away begins from below, where the Loess meets the river, the ravine then slowly works its way into the plateau branching out into wider and wider ramifications.

At other points, far away from the drainage areas, the Loess blends with the other surface deposits in giving rise to broad continuous Steppe plains, devoted in large measure to the cultivation of cereals, and extending in almost unbroken sequence to the foot-hills of the Carpathians. On the virgin soil not occupied by the agriculturist, the abundance of Euphorbiaceous plants was especially noteworthy.

Having thus briefly dealt with the N.W. and W. parts of the

South Central tract under consideration, we may now examine the conditions prevalent at Kharkoff, the capital of Little Russia. The town, though situated between and on the banks of two important tributaries of the Donetz, has, nevertheless, higher ground both on the N. and W., and a casual inspection shows that Loess here plays an important part. This is especially well seen in a ravine, at the foot of the low hill on which the Technological Institute is situated. The base-rock is composed of a greenish, sandy rock, which is very unfossiliferous, having only yielded a few Bryozoa. It is regarded as Oligocene by Professor Barbot-de-Marny. This rock has been denuded in many places, the hollows being completely filled up with a brown-red Loess deposit. At some points, indeed, on one side of the ravine the escarpment appears to be entirely of greensand rock, while on the other the red clay alone is visible. A closer inspection of this clay shows it to possess a very perfect capillary structure, the tubes being filled inside with a carbonate of lime coating, and being evidently originally caused by similar root fibres to those which still penetrate the soil in all directions. Further up the gully, the colour changes from red to white, the transformation being due to the presence of calcareous concretions, aggregated in such large quantities that they simulate a bed of rubbly chalk. In reality, however, this is merely an exaggerated case of an occurrence which is very frequent, and indeed general in the Loess of Southern Russia, and thus brings it into line with similar deposits occurring on the Rhine, in Austria, and in China. Another variety is displayed here, which demands special attention, as throwing some light on the origin of the Black Earth. A close examination enables us to trace a gradual transition from the ordinary yellow-red sandy clay, through a Loess moderately rich in humus materials, to a small, but distinctly-marked layer of Black Earth, which forms the surface-layer in the cliff-face.

A similar relationship on a far larger scale was observed by me while visiting the Bielgorod district. Here, in a small cutting, or quarry on the Steppe, are to be observed some five feet of ordinary Loess, rich in quartz-grains, surmounted by four feet of dark-brown "Black Earth" (this is scarcely ever truly black, being more usually of a dark-brown colour). The latter also contained an innumerable quantity of fair-sized (one-eighth of an inch in diameter) grains of quartz, which glittered brilliantly in the strong sunlight. Close to the point of junction, no sharp demarcation line could be drawn, little seams, or folia, of Black Earth having been formed in the Loess itself. Such inter-bedding, frequently observed, has led me to the conclusion that Black Earth is really a humus-rich modification of Loess, and other facts tend to confirm this view.

In this connection also an interesting section at Kharkoff may be mentioned. It consists of a hollow in the greensand rock, which has been since filled up by very varying materials. Thus at the base is a soft sandstone, following the slope of the little basin. Above it lies a ferruginous sand, which in turn is covered by true Loess. The upper part becomes very rich in humus, and finally

passes into a layer of true Black Earth. The whole is only about three feet in thickness.

The above must not be confounded with a similar occurrence which differs only in the fact that the humus occurs near the base, instead of at the upper part of the Loess. This character is very frequent, and may perhaps have a special significance, but I have been unable to obtain sufficient evidence bearing on this point.

The following conclusions may be formulated:—

1. In general the Russian Loess contains quartz grains of approximately equal size.

2. It is usually unstratified, but in certain districts possesses well-marked stratification at the base.

3. It possesses typical capillary structure.

4. It has a tendency to split in a vertical direction, giving rise to perpendicular walls.

5. It is often very rich in carbonate of lime and humus.

Finally, in its wider sense it may be distinguished—

(A) By its irregular vertical and horizontal distribution.

(B) Its practical independence of the subjacent strata.

It would be interesting to know how far (B) is an absolute truth. It seemed to me that the calcareous concretions appeared to be more common in the districts adjoining Cretaceous outcrops, that in the Permian districts the Loess was redder in colour, perhaps due to an intermixture of Permian red sands, whilst near the Archæan gneisses mica and felspars are more common constituents. Such changes might indeed be due to wind action alone, as these small peculiarities are often observable some distance from the rock outcrop, to whose presence they may have been originally due. Positive proof or otherwise could only be given after long and patient research.

The evidence adduced would be incomplete without some account of the palæontological contents. Indeed, the results are so similar to those obtained in other parts of Europe, that they lend final confirmation to the view that the Loess of Russia is more or less coeval with the Loess of Central and Western Europe.

My own conchological finds were too meagre to enable me to make absolute statements on this subject; but happily evidence is forthcoming from other sources.

One of these, Mr. Belt's "Steppes of Southern Russia" (Q.J.G.S., vol. xxxiii. 1877, pp. 843–862), contains several lists of the shells collected by him while on a short journey in S. Russia. Amongst those mentioned the familiar forms of *Helix hispida*, *Succinea oblonga*, and *Pupa marginata* may be noticed. Another, Prof. Armachevsky's "Geology of the Tchernigov Government," also contains much local information on this point, but being in the Russian language, is not so readily accessible to the general reader. On p. 16 of the latter work a deposit of Loess is mentioned as occurring near the valley of the Desna, in the above government. It contains calcareous concretions, and lies unconformably on the Cretaceous. The following shells were met with: *Pupa muscorum*, *Succinea oblonga*, and *Helix hispida*. After mentioning a large number of similar cases he

concludes:—"In the Loess, as we have seen, the shells of molluscs are very often met with, belonging to the species *Pupa muscorum*, *Succinea oblonga*, *Helix hispida*, and *Pisidium Henslowianum*. These usually are found aggregated in special localities. Not seldom also occur in it bones of Mammals, in which I myself have found the remains of *Elephas primigenius*, *Rhinoceros tichorhinus*, and *Equus fossilis*."

The Mammoth remains which are so numerous in the Don area also hail from this deposit. Indeed, so common are such Mammalian finds, that bones are constantly being brought to light in all parts of the country.

Thus, whilst I was staying at Hughesevo, the mining centre of the New Russia Company, Mr. Williams, the mines manager, showed me two large bones which had been obtained whilst constructing a dam in the neighbourhood. These proved to be a femur and a tibia, which from the descriptions given of the other parts which were not preserved must have been those of a Bos. In the same locality I obtained shells of *Pupa*, probably from shape and size, of *Pupa muscorum*.

Again, in the N. of the Kharkoff Government, during excavations being carried out on the estates of a proprietor living near Bielie-Polie, a fine *Equus* tooth was met with. These are but two examples, taken from widely-separated points, going to prove how wide-spread the Mammalian fauna must once have been, and how complete is its annihilation. The fauna of the Russian Loess therefore resembles that mentioned by Braun as occurring in the Rhine Valley, and at Toulouse, while the Mammalian remains no less recall those met with all over the European continental area.

Theories as to the Origin of Loess.

Already, in 1845, this deposit had attracted the attention of Sir R. Murchison, but some of the facts which now with longer research have been brought to light, had then escaped his notice. Thus he will not consent to regard the tchornozem (for under this name he includes both the Loess and the Black Earth) as equivalent to the Rhine Loess, because the latter is only found on the sides and bottoms of the great valleys, whereas the tchornozem is found at all levels without relation to the existing form of the land. He also asserts that it has no terrestrial or fluviatile remains (Russia and the Urals, p. 562). He accounts for it as being fine mud or silt, formed in the sea, and extending southwards from the points where the northern icebergs ceased to advance. The marine shells might have been decomposed during slow elevation by aqueous and atmospheric agency. It must, however, in justice be stated that the possibility of its formation in great lakes is suggested.

Of course, all the evidence at present adduced shows Murchison's view to be entirely untenable, and like the similar ideas propounded by Bennigsen Förder and Fallou for the German Loess, it now possesses a purely historical interest. No doubt it was partly based on the proofs of a greater extension of the Aralo-Caspian and Black

Seas which are so abundant in S.E. Russia. (I have sometimes wondered whether such an extension might be the result of the elevation of the sea-level due to the nearer presence of an ice-sheet, such as has been suggested, if I mistake not, by the Rev. O. Fisher, Dr. Croll, and others.)

A far more important suggestion was that made by Sir C. Lyell for the Rhine sandy clays (Principles of Geology, chap. xvi.). The origin of the materials is attributed to glacial action during the ice-period, and he accounts for the homogeneity of the materials as being due to the same cause. The Loess itself is in reality a *fluviatile* silt deposited in the lower reaches of the river by the action of floods. To account for its enormous extent, and considerable elevation, Sir C. Lyell called in the aid of numerous elevations and depressions, although assigning no particular reason for such important earth-changes.

Prof. Heer (Urwelt der Schweiz. p. 521) held that Loess was sand and mud deposited from glacial torrents.

Mr. Belt, in the work above mentioned, and in numerous others dealing with various parts of the globe, regarded the materials as being due to the flooding which would result if an ice-sheet blocked up the mouths of the rivers and occupied the marine basins. I do not know what grounds there are for believing such a formidable advance of ice to have taken place, and although such a great *lake* lying between the ice-sheet and the southern mountain barrier may explain a few features, the vertical irregularities, the great abundance of land-shells, and the want of stratification still remained as great a mystery as ever. Agassiz (Jahrbuch für Mineralogie, 1867, pp. 676–680), lent his powerful support to the lake deposition view.

It was not, however, until the appearance of Baron von Richthofen's, "China," Vol. I. (see chap. v.) that the great forward step was taken in the discussion of the subject, and an explanation was given which satisfied a large number of then existing difficulties. One important factor, the *wind*, had till then been entirely overlooked, and was now at one bound to explain the formation of some of the most prominent deposits met with on the surface of the earth. But if I understand him aright, Baron von Richthofen demands certain physical conditions, which shall be favourable to Loess formation. They are: 1st. An area, which shall be almost entirely unconnected with the main drainage, to use his own words, an "abflussloses Becken."

2nd. Thus deprived of any means of outlet, the water and its contained salts would settle in the hollows giving rise to salt lakes, which finally by evaporation would become salt steppes. These dry lake-bottoms thus exposed are subjected to subaerial action alone, wind being especially active in the redistribution of the component particles. Loess may also be formed directly by the denuding power of wind action alone, quite independently of the above physical conditions.

In the first case, as soon as an exit was provided, denudation began. The salts, previously collected in the soil, are leached out, and the once barren Steppe becomes a fruitful plain, and the

"wilderness blossoms and rejoices like the rose." Indeed, it but adds another to the numerous examples of contrast which so constantly occur in science, for we should scarcely expect dreary salt deserts to be the spots which should subsequently become the richest corn-growing districts of the world.

Supported as the above theories are, by wealth of argument, by wide experience, and by a vast knowledge of the literature of the subject, they must ever remain as central cores round which the the future development of the question shall crystallize.

Criticisms have, however, arisen especially as regards the want of stratification. Thus in the early part of this year Mons. G. Capus (Comptes Rendus, April 19, 1892), argued that the greater part of the Loess, especially in Turkestan, must have been formed under water. He bases this view on the presence of stratification, variations in composition, and the occasional presence of conglomerates, though he admits that many local but small accumulations may be due to wind action.

Prof. Armachevsky has also propounded a theory for the Russian Loess, based upon his observations in the Tchernigov Government. He expresses himself as follows:—

"The action of atmospheric water in sharply-rising places is double. By energetic and unequal action the mass of mineral parts is carried away and deposited in hollows, or fills up any inequalities. By weak and regular action, waters flowing from gentle slopes as small streams, expend their energies in partly wearing away the irregularities which are to be found in those places, distributing their materials over the places themselves. Such an action of the water in sharply rising places, in connection with the fact that the Loess is only found in such places, permits us to assert that the Loess owes its origin to the action of such scarcely-to-be-observed, gentle streams, which, flowing along the slopes from higher to lower positions, distribute their mineral load along the road. The following facts support this view:—

(1) The underlying stratified clays and sands containing gravel show undoubted proof of the action of water. Loess is closely bound with them, so that it is difficult to believe that they have different origins. The sands and clays are deposits formed on dry land by means of flowing water, the action of which was less regular than when Loess was laid down.

(2) Loess in a horizontal direction passes over into stratified sands.

(3) The underlying strata have undergone great denudation, giving rise to inequalities and deepenings afterwards partly filled with Loess.

It will be seen from the above references how different are the views which have been propounded on this subject. In reconsidering the question, it seems advisable to ask: 1st, what was the geological history of the country before the Loess period, and 2nd, what was its physical history afterwards, viz., at the present day.

1st. In Eocene times the whole, or greater part of S. Russia

appears to have been covered by the sea, the shore line being found in the N. of the Tchernigov Government, as evidenced by the broken fragments of Belemnites and Phosphoritic nodules which occur at the base of the Lower Tertiaries. To this period belong the Spondylian Blue Clays of Kieff, similar beds having also been proved to exist in the other governments mentioned at the beginning of this article.

In the Crimea, too, the ubiquitous Nummulites appear to have found a congenial home.

The Northern Continent seems to have slowly advanced southward, for the clays are overlaid by an important series of glauconitic sands, containing amber and plant remains. This succession is well-marked in the Kieff, Kharkoff, and Poltava Governments. Indeed, in Miocene and Pliocene times S. Russia becomes sharply divided into two areas: the Northern half, in which a thickness of unfossiliferous sands (ferruginous or beautifully fine and white), succeed the amber-bearing beds, and separate them from the variegated and freshwater clays which preceded the glacial clays and the Loess; and a Southern half, in which a marine fauna still flourished, although even here, too, the sea was gradually driven back till the present outlines were more or less clearly defined.

Indeed, the facts seem to point to a gradual southward advance of the land area, or, as Professor Suess would have it, retreat of the sea; an advance checked it may be for a time by the presence of an ice-sheet, and the consequent changes involved thereby.

As Professor Suess has pointed out, there appears to be a very intimate relation between the Loess and the Glacial Drift. In N. Russia there is nothing but Glacial Drift at the surface, while in the South the Loess entirely takes its place, but between them is a band, passing into Galicia and Saxony, a band along which the Loess overlies the Glacial Drift, and it is just along this line that the basal stratification is most clearly marked. This relationship appears too striking to be casual, and I am inclined strongly to regard the original constituents of the Loess as being the finely-ground materials due to the combined action of the ice-sheet and the increased drainage activities resulting therefrom. This appeared to be the answer to the question which thus presented itself. Here is a vast deposit in which evidently denudation is now exceeding deposition. Can the original materials of such a deposit have been originally derived from actions which are still proceeding in the same area, or must some other explanation be sought for their origin?

Though the above cause may give a clue to the origin of the materials, other actions may by no means be left out of account. There, are for instance, speculations which may become important if based on sufficient proof. Thus, is the earth sufficiently plastic to be compressed by a mass of ice resting for lengthened periods on the same tract, and if so, would the depression have a corresponding elevation at some distance away? Even a small elevation in the S. of the Russian Empire would be sufficient to convert the central tracts into an "abflussloses Becken;" but I know of no evidence

in favour of mountains able to cut off the rain-laden winds such as are demanded by Richthofen. On the whole, S. Russia does not seem to satify the conditions favourable to the origin of a true wind-blown Loess. If such elevation did, indeed, take place, it would be sufficient to convert the region between the ice-sheet and the sea into one vast tundra or series of tundras. Even without such elevation, the effect of the presence of the ice-sheet upon the river-drainage would perhaps be of such a character that we at the present day might be almost unable to grasp its full significance.

2nd. Leaving these speculative ideas, let me ask what are the actual physical agencies which are at work during the course of a year, and what light, if any, they throw on the points under discussion. The autumn may be taken as a convenient starting-point. Immediately the summer heats are over, rain becomes more frequent, thoroughly saturating the porous soil, which during the early frosts is rent in all directions owing to the freezing of the contained moisture. The winter snows which follow, protect the land for four or five long months from further denudation, whilst overhead they are whirled into a fierce blinding metiel by the piercing east wind. It is not till March that the denuding forces are again let loose.

With the return of warmer weather, ice and snow begin to melt. Every small stream becomes a rolling torrent, every river spreads out on both sides into a vast lake area. The flood-gates are opened, and the denuding action that takes place in the upper reaches is only equalled by the deposition which must occur in the lower parts of the river-basins.

One or two examples may show the energy which is thus unlocked at this period. I have seen trickling streamlets which could be crossed at one step in summer converted into rushing torrents 30 feet wide, and some 20 feet deep, bearing away in their mad rush the remains of the wooden bridges which had been thrown over them higher up the stream. Sometimes during summer very curious contrasts may be witnessed. Thus, at the village of Mandreekin, near Hughesevo, three great wooden ice-breakers were standing in a dry bed, whilst near by rose up two massive stone abutments, the sole remnants of what had once been a solidly-built bridge. The only trace of the river consisted of two stagnant pools, separated by a considerable distance of marsh and dry dusty land. This, indeed, is the summer condition of the minor Russian rivers. One more example will suffice. In spring the Psiol regularly overflows its banks, and rowing is indulged in to a great extent by neighbouring landowners (whose property is often to a large extent under water), the only danger being due to the trees which are sometimes completely hidden under the flood-waters. This flooding, again, is the rule with all the Russian streams.

It is remarkable with what rapidity the waters disappear as soon as the summer sun attains its full power. Roads previously impassable become tracks deep in sand, and the wind or the air-currents caused by differences of temperature have abundant material

upon which to exert a redistributive action. On the Ekaterinoslav Steppes on a hot day, we have observed as many as ten or twelve dust-clouds (resembling water-spouts when seen at a distance), rushing along over the vast plains, unimpeded by any obstacles, and frequently attaining a height of from 30 to 40 feet.

What the force of the wind sometimes is may be judged from the fact that on some rare occasions the waters of the river Don have been driven back under its influence for a distance of over eight miles, the ships remaining high and dry, while the Sea of Azov is then evidently seen to lie in a saucer-like depression. Such a force is evidently one by no means to be ignored in considering the physical activities which are at present altering the earth's surface.

It is especially interesting in the more hilly districts to see the clouds of dust being driven up the long slopes, shewing the means by which high elevations may be covered with Loess. Thus in the annual cycle the principal physical forces coming into play are—1. Rain. 2. Frost. 3. Rivers in Flood. 4. Wind. With the greater differences of temperature which previously existed, the first three would probably be far more active, that is to say, if the river-beds were defined as they are now.

It will be noticed that our area is now drained by three important rivers, the Dnieper, Donetz, and Don, whose basins separate higher plateaux lands. Thus on the W. of the Dnieper is a Sub-Carpathian table-land, between the Dnieper and the Don is a Central table-land. Finally, to the E. is the Volga table-land. All these exceed 500 feet in height, while the river-basins between them never reach that level. It is very remarkable to notice that each of these rivers is pressing on the eastern edges of the plateaux which abut against them as steep escarpments. Von Buch considered this westward advance of the river-valleys as being due to the rotation of the earth.

The Loess occupies the upper summit of many of these escarpments, and it has seemed to me that the river Dnieper must have cut out its present valley since the Loess period. The matter is one that seems to call for further study. It is remarkable, for instance, that the Dnieper for a long distance follows the line of the Archæan axis, yet having a thin band of gneisses on the left bank. Below Ekaterinoslav it cuts straight across the Archæan rocks, giving rise to the famous cataracts which render the river useless for navigation below the town of Ekaterinoslav. It seems probable that the Dnieper once ran at the point of surface junction between the gneisses and some softer beds, but that now the latter have been denuded and the river has cut its bed deep into the underlying gneisses.

I cannot refrain from further calling attention to the present physical geography of S. Russia. The Crimea elevation with its volcanic hills appears to have served as a barrier against which the land has been piled up, separating the Sea of Azov from the Western tongue of the Black Sea. But this does not explain the striking parallelism between the course of the three southern rivers. It may be only a coincidence, but it may be also that some deeper cause

underlies this phenomenon. Not having visited the southern reaches of these streams it would be unwise to start a theory without actual evidence to support it.

At the present day there is still some apparent tendency to Southern advance on the part of the Russian Continent. The eruptive activities in the Taman peninsula are causing elevations which may eventually close the entry to the Sea of Azov altogether. Meanwhile the Don is pouring its mud-laden waters into the northern end of the same sea. Shipping, that within the memory of men now living, could come right up to the town of Taganrog, has now got to anchor 16 miles outside in the roadstead. Von Baer indeed, held that the Azov Sea is undergoing a gradual elevation.

Similarly the N. part of the Caspian Sea is slowly retiring or drying up, and the great rivers, as the Volga and Dnieper, are becoming silted up. This fact was strongly impressed on my mind while our steamer was fast aground for about twelve hours on a sand-bank in the latter river, while the peasants apparently standing in mid-stream were only up to their waists in water.

The following may possibly represent the sequence of events:—I. The Loess particles may be originally derived from the finely ground material resulting from the wearing of the subjacent beds by the ice-sheet. II. The same have been deposited in tundra-like depressions under the influence of slowly-moving waters, or by the action of rivers in flood. III. This deposit under more temperate conditions dried up, and was then suitable material for the redistributive action of the wind.

The redistributive actions are still at work, but denudation is rapidly proceeding, giving rise to the broken ground which lends such special features of beauty and even of wildness to such towns as Kieff, Poltava, and Kharkoff. Floods every year transfer Loess to the lower grounds, whereas wind on the contrary tends to carry it higher in a vertical direction. Plants, with their penetrating roots, steppe-rats tarantulas, and worms all help to break up the porous soil, and thus assists the continuance of the redistribution.

The Loess country is, as has been already stated, one of the chief wheat growing districts of the world. It satisfies in every particular the conditions which Berthelot demanded as being favourable for the fixation of Nitrogen (Comp. Rendus, cvii. 20, 852, etc.), viz. a soil of sandy and clayey nature, which admits of free access of air and is not too moist. Also it must have been rich in potash and poor in nitrogen.

Of course the weathering of the granite rocks on the W. of the Dnieper must be constantly adding fresh materials, which, under the action of the wind, will form part, or has helped to form a part, of the Loess as it is met with in those areas. Indeed, I have already mentioned in this connection that in the neighbourhood of the Archæan rocks the Loess appears to be much richer in micaceous materials.

The belief in an ice-sheet and the traces of its action are so widespread that I need scarcely offer an excuse for using it so freely as a primary cause in the above article.

Again, I have been compelled to call in the action of water, either as slowly moving rills, as rivers in flood, or filling tundra-like depressions to explain some of the observed phenomena, especially the basal stratification. Nevertheless, the other facts pointing to a different conclusion are too numerous to allow me to accept Prof. Armachevsky's views, and regard the whole deposit as due to the action of atmospheric waters.

Lastly, I have attempted to review the chief physical influences acting on the region at the present day, and conclude therefrom that the actual condition of the Russian Loess is due to a multiplicity of causes, which have been acting (with greater force, perhaps, in former centuries) through a very long period of time. Not the least of these, as explaining the abundant land fauna and the vertical distribution, is the wind which has full play on the boundless Steppe.

I also trust I have pointed out that behind the origin and distribution of this great deposit lie questions of physical geography of the greatest interest, questions which alone can be solved by a careful and detailed special examination of the country dealt with in these pages.

VIII.—Granite.

By Thomas R. Struthers;
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THE commonly accepted theory of the origin of granite is that, in view of indications that it had been subjected to great pressure, it was formed deep in the earth's crust in a molten state, and, after consolidating, thrust up through it, or exposed at the surface by denudation. This theory is not altogether satisfactory, being equivalent to an assertion that a stately building was first constructed and its foundation laid afterwards. Like some other unsatisfactory theories, it has been so often reiterated that it is tacitly assented to as authoritative, on the principle, we suppose, that what everybody says must be true. There are existing conditions analogous to those under which the trappean rocks were formed, as illustrated by modern submarine and subaërial erupted rocks; but the conditions under which primitive granite originated are not now represented in any part of the world. There is little difficulty in tracing the inorganic constituents of all rocks back to granite; but there is no proof that granite was derived from any pre-existing rock.

According to Hutton, the fundamental rock of the earth's crust consists of the reunited *débris* of older continents, which in like manner may have been formed of the reconstructed wrecks of anterior terrestrial areas, and so on backward *ad infinitum*. In interpreting Hutton's theory Sir Charles Lyell, in his "Principles," attributes to him a belief that "alternate periods of general disturbance and repose had been, and would for ever be, the course of nature." We do not, however, suppose that Hutton meant to insist on this illogical hypothesis, and as it was based only on *assumed*

facts, it may now be ranked among the ingenious speculations which, in early times, preceded the advance of science to such a degree, but hypotheses, however ingenious, have little prospect of being accepted now-a-days, unless based on incontrovertible facts.

It must be admitted, however, that although the first principles of the Wernerian and Huttonian 'theories' of the earth are unsatisfactory, the *hypotheses* of these propounders of the two opposite geological doctrines (we cannot consider them entitled to rank as theories) have been extremely useful in giving an impetus to the accumulation of knowledge and in the search for truth; whilst in the course of their investigations both Werner and Hutton described and explained many geological phenomena, and thus rendered important aid to future explorers, who again did good service to science, even in the correcting of such errors as may have been made by the original observers.

Stratified rocks must originally have been derived from unstratified rocks; and the inorganic constituents of the former may be traced back to granite, while the direct relation of that rock to gneiss, quartzite, mica-schist, and clay-slate, intimately associated with it, is so evident as to leave no room for doubt. It may also be observed that erupted rocks, whether volcanic, or trappean, have apparently been derived from granite, for in common with them it consists mainly of silica, alumina, potash, soda, lime, magnesia, and iron in varying proportions; and according to Beete Jukes, "if we could follow any actual lava stream to its source in the bowels of the earth, we should in all probability be able to mark in its course every gradation from cinder or pumice to actual granite."

The hydrothermal conditions under which granite was formed are generally acknowledged, but these conditions were peculiar to a particular period of the world's history, when a sea of a high temperature overspread its entire surface before any dry land had appeared. The first terrestrial surfaces would necessarily consist of portions of the sea bottom elevated by volcanic agency after it had cooled, consolidated, and contracted. Had no such upheaval taken place there would have been a foundation laid, but there could have been no superstructure of strata. We may also remark that from the circumstance that granite frequently assumes a bedded form, and in many instances contains fragments of the older stratified rocks evidently enveloped when it was in a molten state, and also that it has been observed in junction with them, it would appear that outbursts of the newer granite must have taken place for some time after the elevation of the first dry land, from which the sedimentary rocks had been derived.

The structure of granite indicates pressure during consolidation; but in accounting for this it is not necessary to adopt the current theory of its origin, for the sea, the depth of which we may estimate at two miles, would exert a pressure of several hundred atmospheres. The commonly adopted theory of the origin of granite appears to be based upon the Huttonian hypothesis that "it was elevated from the ocean, raising up the strata before it." This is partly true, for

the granitic foundation of the earth's crust must have participated in any upward movement of the superincumbent strata; but there must have been a considerable extent of granite or other primeval rock raised above the sea-level before any strata could be deposited. The bedding of granite must have taken place when the material was in a molten or plastic state, free to flow. The beds are, as a rule, superimposed upon amorphous granite, and have been traced to rents, not only through the subjacent granite, but through overlying gneissose and schistose strata on which they have been spread. The distinction between bedded and amorphous granite is well-known to granite cutters, the former having what they call a 'greek'—a cleavage plane—which we would suppose to be parallel with the bedding, and a key to the extent to which the rock has been disturbed by convulsions affecting the earth's crust. Bedded granite is widely distributed in the British islands, and many other parts of the world. It was known to the early geologists as stratified granite, in accordance with the Wernerian supposition that "granite fell down first from the universal dissolving liquid." Lyell, in his Manual, observes: "Granite often preserves a very uniform character throughout a wide range of territory, frequently forming hills of a peculiar rounded form, clad with a scanty vegetation. The surface of the rock is, for the most part, in a crumbling state, and the hills are often surmounted by piles of stones like the remains of a stratified mass, and sometimes like heaps of boulders, for which they have been mistaken. The exterior of these stones, originally quadrangular, acquires a rounded form by the action of air and water, for the angles and edges waste away more rapidly than the sides. A similar spherical structure has already been described as characteristic of basalt and other volcanic formations, and it must be referred to analogous causes, as yet but imperfectly understood."[1] Lyell gives an illustration from the Sharp Tor, Cornwall, showing a pile of granite consisting of several courses, and presenting the appearance of the remains of successive stratified deposits; but we have no hesitation in saying that it is a fine example of bedded granite originally discharged in successive submarine sheets, and now fractured, weathered, and reduced by the natural forces to which it has been subjected during the course of ages.

The 'tundra,' or moorland of Siberia, extending along the shores of the Arctic Ocean, presents a good illustration of the physical features produced by bedded granite. Here and there the rock rises in smooth, rounded, protuberances above the general level, which is a monotonous flat, covered with moss; and, as might be expected, scarcely a tree is to be seen. There are many things which the commonly received theory of the origin of granite cannot account for; and it is more reasonable, and more in accordance with existing phenomena, as well as with experimental evidence, to hold that it was formed by the cooling of the exterior of our globe under the primeval deep, and by additions due to outbursts of newer granite from the heated interior, the elastic force of which would be brought

[1] Lyell's "Students' Elements of Geology," 3rd Edition, 1878, p. 552.

into action by the contraction of the rocky barrier by which it was environed; while the modifications produced by seismic and volcanic force, together with exposure to destructive chemical and mechanical agencies through long-continued periods must be taken into account in endeavouring to arrive at a correct understanding of its lithological and petrological aspects. Without enlarging on the subject, it may only farther be remarked, that the thickness of the solid exterior of the earth is commonly reckoned to be about 45 miles; and if we deduct 10 miles for the thickness of the stratified rocks (which is practically an over-estimate, for it represents the depth of all the systems, or differentiated assemblages of strata tabulated in the order of time; and the series is nowhere known to exist in its entirety) we have 35 miles of the crust to account for. This is, properly speaking, the 'foundation' of the earth from which have been elaborated, by chemical and mechanical agency, the more superficial accumulations which contribute so largely to the convenience and comfort of the human race.

Some geologists continue to distinguish granite from the other unstratified rocks by the term 'Plutonic,' and others class it as a trappean rock. Its varieties might more properly be described as Cryptogene (of hidden origin) whatever shades of difference there may be in their composition, if they exhibit evidence of a common origin by their position and structure; for in granitic—let us say cryptogene—rocks there are many departures from the normal type, which consists of quartz, felspar, and mica; the hornblendic or syenitic varieties forming a stepping-stone to the trappean syenites, and indicating a close relationship between the two classes of unstratified rocks under reference.

NOTICES OF MEMOIRS.

I.—The St. Bees Sandstone and its Associated Rocks.[1] By J. G. Goodchild, F.G.S., H. M. Geological Survey.

THE author reviews the history of opinion upon the classification of the New Red Rocks of Cumberland and Westmoreland, and then gives the following as the maximum thickness, general succession, and probable equivalents elsewhere of these rocks:—

New Red Series (Upper Division).

	Maximum observed thickness in feet.
(5) Red marls with rock salt and Gypsum	950
(4) St. Bees Sandstone, with the following subdivisions:—	
(*d*) Waterstones; (*c*) zone of tile red phases; (*b*) dull Red Sandstone with local bands of fine conglomerate and occasional pebbles; (*a*) zone of variegated sandstones. In all	2000
(4*a*) Graduates downward into—	
(3) Gypsiferous marls with local conglomerate at its base...	300
Magnesian Limestone Group.	
(2″) Magnesian Limestone	25
(2′) Plant beds...	150
Lower New Red.	
(1) Penrith Sandstone: the Brockrams	1500

[1] Read before the Brit. Assoc., Edinburgh, August, 1892, in Section C (Geology).

EXTENSIVE UNCONFORMITY.

There is a perfectly unbroken downward succession as far as the conglomerate at the base of (3); and, therefore, as (4*c*) is admitted on all hands to be of Triassic age, the remainder of (4) and the whole of (3) must be of Triassic age also; (3) lies indifferently upon either member of (2) or upon the upper part of (1); it is therefore slightly unconformable to the beds below. These are admitted on all hands to be Permian; therefore the break between the Trias and the Permian is at the base of (3). The author considers that the whole of these rocks form the natural basement beds of the Neozoic rocks, and that the dividing line between the Palæozoic rocks and the Neozoic age should be taken somewhere between the Red Rocks of the Salopian type (to which he would restrict the term Permian) and the true New Red, as the term is here employed. He considers that the New Red proper bears the same relation to the Jurassic and Rhætic Rocks that the Upper Old Red Sandstone does to the Carboniferous, and that the Salopian Permian may possibly occupy the same relation in regard to the Carboniferous rocks as the Glengariff Grits do to the Silurians. Some at least of the Salopian rocks may be simply Carboniferous rocks stained by infiltration from the New Red.

The author regards the St. Bees Sandstone as mainly equivalent to the Bunter, and proposes that the term Bunter Marls should be applied to the marls which here (and in Devonshire, etc.) occur at the base of that subdivision.

II.—THE IGNEOUS ROCKS OF THE NEIGHBOURHOOD OF BUILTH.[1] By HENRY WOODS, B.A., F.G.S.

AN account of the geology of the Builth district was given by Murchison in the "Silurian System" (1839), since which scarcely anything has been written on it. A series of igneous rocks, associated with beds of Ordovician age, stretches from near the town of Builth to beyond Llandrindod. In this paper the author confined himself to the southern half of this area, giving a preliminary description of the distribution and characters of the rocks met with, namely, diabase, rhyolite, porphyrite, andesite, and ashes.

III.—ON THE RELATIONS OF THE ROCKS OF THE LIZARD DISTRICT.[1] By ALEX. SOMERVAIL.

THESE rocks include the hornblende-schist, serpentine, gabbro, granite, etc., which the author regards as all belonging to the same period of geological time, and to have segregated or separated out from each other during the cooling of a homogeneous magma.

There seems absolute evidence in the field to show that the serpentine is a non-intrusive rock, that it was the first portion of the magma to cool, and is broken through by all the other rocks, but that it is intrusive into none.

The relations between the serpentine and the diorite and portions

[1] Abstracts of Papers Read before the British Association, Edinburgh, Aug. 1892.

of the granulitic rocks are those of segregation, and not of intrusi as many sections show these rocks associated together in gr alternating bands with a concentric-like structure with compl transition varieties, but with no sign of intrusion on the part either. These concentric-like structures, which are certainly origi —due to cooling—have been subsequently displaced and broken so that the now isolated portions are mistaken for intrusive tong of serpentine or included fragments of hornblende. When follow out they resolve themselves into what were once connected mass

While the main masses of these rocks have separated out fr each other, and cooled in the order of increasing acidity, there a seems absolute proof in the field that the intrusive dykes in serpentine, consisting of diorite, granite, complexes of these and a of gabbro, are but portions of the uncooled magma of the ma masses which were able to penetrate the serpentine.

That the main masses and the dykes are of one and the same a is evident, not only from their mineral composition and lithologi aspect, but also from the fact that all these rocks are inter-related for example, the gabbro and diorite dykes coalesce, and dykes of t former have margins of the latter. The diorite contains inclusio of gabbro, and in some instances inclusions of the latter conta others of the former. The granulitic rocks, diorite, and gabbro occ as a regular interbanded series, and there are also schists of the complexes.

The facts seem to warrant the following conclusions:—

1. That all these rocks belong to one geological epoch; that th relations are principally those of segregation or separation, and a lesser degree of contemporaneous intrusion on the part of the le basic and more acid portions of the magma.

2. That the olivine portion of the magma now forming t serpentine was the first to cool, followed by the others in the ord of their increasing acidity.

3. That the serpentine is a non-intrusive rock, and one into whi all the other types of rock have been intruded, the granite intrusio being the latest.

IV.—On the Presence of Fossils in the "Azoic" Rocks Brittany. By M. Charles Barrois, Comptes Rendus des Séanc de l'Académie des Sciences, Vol. CXV. pp. 326–328, August 8 1892.

A BED of quartzite containing crystalline scales of graphite intercalated in the gneiss of Morbihan. This gneiss pass laterally into mica-schists by the disappearance of felspar. represents the azoic schists metamorphosed by the injection "granulite." The graphitic quartzite can be followed for a co siderable distance both to the north-east and south-west of t Vannes-sheet of the Survey Map, into regions less affected by t granulite. It is then found to be interstratified with mica-schist M. Barrois has also determined the presence of the same band the north of Brittany, where the rocks are far less affected by t

intrusive granulite and the graphitic quartzite is represented by carbonaceous quartzites and phtanites. These rocks underlie the phyllades de St. Lô, and pebbles of them are found not only in the Cambrian but also in pre-Cambrian conglomerates. The carbonaceous phtanites of this horizon occurring at Lamballe (Côtes du Nord) contain radiolarian remains which have been identified by M. Cayeux as belonging to the group of the Monosphæridæ. These are the oldest fossils known in France, and probably in the world. The discovery is also interesting because it confirms the theory of M. Michel-Lévy as to the origin of the granulitic gneiss.

REVIEWS.

I.—Notes sur l'Histoire et la Structure géologique des Chaines Alpines de la Maurienne, du Briançonnais, et des Régions adjacentes. Par M. W. Kilian. Bull. de la Soc. Géol. de France. 3ème s., vol. xix (1891), pp. 571–661.

Sur l'allure tourmentée des Plis isoclinaux dans les Montagnes de la Savoie. Par M. Kilian. *Ibid.* pp. 1152–1160, pls. xxv.–xxvi.

THE first of the above papers contains the results of a series of explorations carried out by M. Kilian, on behalf of the Geological Survey of France, in a portion of the French Alps between the upper valleys of the Isère, the Italian frontier, and the upper valley of the Ubaye, and they are published in advance of a more complete monograph on the subject. The author's researches have been mainly devoted to the band of sedimentary deposits intercalated between the crystalline zones of Mont Blanc and of Mont Rose, which are comprised in the second and third of the Alpine zones of Lory, and referred to, in the recently published work of Dr. Diener on the Structure of the Western Alps, as the "Zone of the Briançonnais."

The author treats first of the stratigraphical succession of the region, and describes the grey lustrous schists, and the calcareous talcose schists, situated beneath the Triassic deposits, which have a great extension between Bardonnèche, Oulx, and Cezanne (Italy), as well as in the Queyras district. In the schists are beds of blackish crystalline limestone, also some quartzites, and in certain localities they are penetrated by numerous intrusions of serpentine. Near the source of the Ubaye these rocks gradually pass down into micaceous schists alternating with beds of gneiss. The lustrous schists were regarded by Lory as of Triassic age, but M. Kilian considers them to be Palæozoic, possibly Carboniferous, or even more ancient.

The Carboniferous rocks of the region form the great anticlinal of the third zone as well as some of the anticlinals of the second zone, and above them are beds of green phyllites, grits, and conglomerates, resembling the verrucano of the Swiss Alps, which from their stratigraphical position beneath the Trias are referred to the

Permian, although at present there are no fossils known from these rocks to establish their real position. Above the supposed Permians is a great series of rocks, the lower portion of quartzites, succeeded by beds of gypsum, dolomites and dolomitic limestones, and coloured schists. The greater part of this series is considered by the author, on the evidence of fossils, to belong to the Trias, but it probably includes fragments of Liassic and Jurassic rocks which have been caught up and involved in the folds of the older strata. The author attempts to show that the beds of gypsum and the dolomitic limestones in this series are merely lateral modifications of the same deposit, so that in some places the gypsum completely replaces the limestones, whilst in others it occurs either in the upper or lower portions of the series.

Next above the Trias, the Lower Lias is represented by dark limestones usually filled with Belemnites, and the Upper Lias by dark schists or shales. The author has traced out a well-marked calcareous breccia in the Lias; and in the Upper Jurassic also, there is a definite band of brecciated red marbles containing Ammonites and Belemnites of the group of *Duvalia*.

The Tertiary rocks in this region consist of Nummulitic limestones and schists, and the existence is proved of a micaceous and quartzitic breccia of the same age, which had previously been considered Triassic.

In a region so disturbed as the Alps, it must be difficult to distinguish between real and apparent overlap and unconformity; the author considers, however, that there is evidence of a real overlap in the Permian rocks, though not of great extent; whilst the overlap of the Triassic strata on the other hand appears to have been very extensive. There is also both an overlap and unconformity between the Upper Jurassic and the Triassic limestones near Guillestre and Castellet. The great overlap of the Nummulitic rocks is established by the fact that these rocks rest successively on the Lias, the Triassic limestones, gypsum, and quartzite, and in the Basses-Alpes, to the south of the present region, on Senonian rocks; thus indicating the existence of movements subsequent to the Senonian, for fragments of these latter are present in the earliest Eocene beds.

The extent and intricacy of the folding and dislocation of this portion of the Alps are very strikingly shown in the various sections figured by the author, and more particularly in the two remarkable photographs (pls. xxv.–xxvi.) accompanying the second paper, which show a natural section of the escarpments of the Nantbrun Valley.

II.—Borneo: Its Geology and Mineral Resources. By Dr. Theodor Posewitz. Translated from the German by Dr. F. H. Hatch, F.G.S. (London: Edward Stanford, 1892, pp. 495; with Geological and other Maps.)

A THREE years' residence in Borneo gave the author an opportunity of becoming acquainted with the leading features in the geology of that island; he has also devoted himself to an exhaustive

study of the literature of the subject, much of the best information being in Dutch and but little known out of Holland. In the present work he has summarized all that is known concerning the Geography, Geology, and Mineral Resources of Borneo.

The German edition was published in 1889, and although three years have now elapsed, the information brought together will be of great value to all who are interested in the island. Portions of its large area, however, remain wholly unknown to Europeans.

The formations represented, comprise (1) the crystalline schists, the old slate formation of Devonian (?) age, and certain eruptive rocks: these constitute the mountain chains and their spurs, but the rocks, though grouped together for convenience, are of different ages, and they have not been properly separated. Granites, diorites, gabbros, and serpentines occur. Some of the crystalline rocks may be Archæan, and although the Devonian age of certain slates is suggested by their fossils, these are so badly preserved that no exact determination could be made. Certain beds of limestone, sandstone, conglomerate, and slate (2), are grouped as Carboniferous, from the fact that Encrinites, *Fenestella*, *Stenopora*, and a few other fossils have been found in some of the limestones.

Next in point of order amongst the strata recognized, are (3) Cretaceous beds. These are known only over a very limited area. They comprise grey marls and greenish-grey sandstones, and have yielded species of *Avicula*, *Arca*, *Lima*, *Modiola*, *Trigonia*, *Goniomya*, *Pholadomya*. *Hemiaster*, etc.; but their age cannot be said to be very decisively determined.

All the above-mentioned formations are found to occupy portions of the Mountain-land; the highest elevation in which, Kina-balu, is estimated at about 12,000 feet.

The Hill-land, which rarely exceeds 200 to 300 feet in height, is formed of (4) Tertiary strata. The beds are mainly of Eocene age and comprise sandstones and shales with coal-seams, marls, and limestones. These are pierced in numerous places by eruptive rocks, mostly "hornblende-augite-andesites." The Eocene strata have yielded Nummulites, Corals, and Mollusca. Some of the Mollusca may be compared with those obtained by M. Verbeek from the Tertiary strata of Sumatra, and described by Dr. H. Woodward (Geol. Mag. 1879, pp. 441, 492, 535); there do not, however, appear to be many species common to the two islands. In Borneo there are some later Tertiary strata (Miocene?); but owing to the absence of fossils, their age could not be more definitely determined.

The Plains are covered by sandy clays and conglomerates (5), grouped as Diluvium; and the Marshes are made up of (6), Alluvial formations, or recent marine and fluviatile deposits. Reference is also made to Cave-deposits and to recent Coral-reefs.

A large part of the work is devoted to the subject of "Useful Minerals." These include Coal, which occurs in the Eocene, and also in the so-called Miocene deposits; but chiefly in the former. It occurs in considerable quantity, but has been comparatively little worked. Full particulars are given, with analyses. Gold occurs in

both Alluvial and Diluvial deposits, and in the older rocks (No. 1). Diamonds occur in the Post-Tertiary deposits, but have not yet been found *in situ*. Platinum and ores of Antimony, Mercury, Iron, Copper, and Silver, have been obtained. Ores of Lead and Zinc occur, but it is said that they will not pay for working. Various other ores have also been found. The occurrence of Salt-beds is noted, and there are also Warm Springs.

The notes appended to the work by the author should have been inserted in their proper place in the body of the work by the editor, and he would have greatly added to its usefulness if he had provided an index. The chief value of the work will be in reference to the Economic Geology of the Island; but scientific explorers will find it of great service on all matters connected with the Geology of Borneo.

III.—The Student's Handbook of Physical Geology. By A. J. Jukes-Browne, B.A., F.G.S. Second Edition. (London: George Bell & Sons, 1892.) Price 7*s.* 6*d.*

THE first edition of this work was briefly noticed in the Geological Magazine for 1884 (p. 461). During the eight years that have elapsed much information has been gathered on the subjects dealt with by the author, and he has enlarged his work, more especially with reference to Volcanoes, the processes of Disintegration, Oceanic deposits, Metamorphism, and Mountain-building. Faults and flexures receive additional illustration in the matter of thrust-planes. We are not altogether confident that the author has done wisely to increase the bulk of his volume from 514 to 666 pages. His aim, as stated in the first edition, was to provide a book of modest pretentions, at a moderate price, for the use of geological classes. Even then, with the volume dealing with Historical Geology, the student had to encounter over eleven hundred pages before he had traversed the field of geology traced out for him; and it is difficult to get students to read big books. Be this as it may, the author has brought his work up to date in a most painstaking manner; and the reader will find a full account of the geological agencies now in operation, of rocks and rock-masses, and of the processes which have led up to the present physical configuration of the earth's surface.

The author objects, as others have sometimes objected, to the use of the word Denudation; but to supplant a familiar and well-understood term is no easy matter. One authority has proposed to establish the word 'Abrasion;' Mr. Jukes-Browne proposes the word 'Detrition.' One of the stumbling-blocks introduced into modern Geology is the attempt to change well-known names, whether in Physical Geology, Stratigraphy, or Palæontology. Changes may not affect the student in his days of class-learning, but when he becomes a worker, he must learn the old as well as the new terms, and every addition, whether useful or otherwise, must needs be a burden.

On Glacial subjects the author has enlarged his views, and he is prepared to admit "that land-ice can in some way give rise to the formation of a Boulder-clay." In cases, however, where there is a difference of opinion amongst geologists, care is taken to state the alternative views.

The work is illustrated by 214 figures and two plates; and altogether it forms an excellent and comprehensive handbook for advanced students.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 9th, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.

The President announced that the Naturforschende Gesellschaft of Dantzig will celebrate their 150th Anniversary in that town on January 2nd and 3rd, 1893.

The following communications were read:—

1. "A Sketch of the Geology of the Iron, Gold, and Copper Districts of Michigan." By Prof. M. E. Wadsworth, Ph.D., A.M., F.G.S.

After an enumeration of the divisions of the Azoic and Palæozoic systems of the Upper and Lower Peninsulas of Michigan, the Author describes the mechanically and chemically formed Azoic rocks, and those produced by igneous agency, adding a table which shows his scheme of classification of rocks, and explaining it.

The divisions of the Azoic system are then described in order, beginning with the oldest—the Cascade Formation, which consists of gneissose granites or gneisses, basic eruptives and schists, jaspilites and associated iron ores, and granites.

The rocks of the succeeding Republic formation are given as nearly as possible in the order of their ages, commencing with the oldest:—Conglomerate, breccia and conglomeratic schist, quartzite, dolomite, jaspilite and associated iron ores, argillite and schist, granite and felsite, diabase, diorite and porodite, and porphyrite. The author gives a full account of the character, composition, and mode of occurrence of jaspilite, and discusses the origin of this rock and its associated ores, which he at one time considered eruptive; but new evidence discovered by the State Survey and the United States Survey leads him to believe that he will have to abandon that view entirely.

In the newest Azoic formation, the Holyoke formation, the following rocks are met with:—Conglomerate, breccia and conglomeratic schist, quartzite, dolomite, argillite, greywacke and schist, granite and felsite (?), diabase, diorite, porodite, peridotite, serpentine, and melaphyre or picrite. The conglomerates of the Holyoke formation contain numerous pebbles of the jaspilites of the underlying Republic formation; a description of the Holyoke rocks is given, and special points in connexion with them are discussed.

The Author next treats of the chemical deposits of the Azoic system, gives a provisional scheme of classification of ores, and discusses the origin of ore deposits.

The rocks of the Palæozoic system are next described, and it is maintained that the eastern sandstone of Lower Silurian age underlies the copper-bearing or Keweenawan rocks. The veins and copper deposits are described in detail, and the paper concludes with some miscellaneous analyses and descriptions, as well as a list of minerals found in Michigan.

2. "The Gold-quartz Deposits of Pahang (Malay Peninsula)." By H. M. Becher, Esq., F.G.S.

The gold-quartz deposits of Pahang which traverse an extensive series of slates, sandstones, and dark-coloured limestones, sometimes more or less metamorphosed, and probably of Palæozoic age, occupy the low-lying hill-country on the eastern side of the central granitic mountain-range. The prevailing dip of the strata is eastward.

In some places the auriferous rock penetrates adjacent intrusive syenites, but has not been traced in connexion with the main granitic 'massif' which is generally considered to be the matrix of the cassiterite found in the 'Straits' alluvial Tin-fields.

The gold occurs in lodes and irregular formations, which, however, are not distinguished from one another by any hard-and-fast line; the difference depends on the size, shape, and continuity of the quartz veins, though even the lodes seldom maintain their regularity for more than a few score feet. The quartz often occurs in very narrow veins intersecting one another to form what may be called 'stockworks.' It is probably from these minute veins that the alluvial gold is derived. In the Raub mine numerous rich veinlets occur in a certain zone where the whole slate-rock is charged with iron pyrites, probably auriferous. Many 'stockworks' are intimately associated with dykes or intrusions of a rock which may be called trachyte-porphyry, and these igneous rocks are decomposed where prominently associated with auriferous quartz.

3. "The Pambula Gold-deposits." By F. D. Power, Esq., F.G.S.

The Pambula Gold-field is situated in the parish of Yowaka, County of Auckland, in the South-eastern corner of New South Wales.

The lodes are different from ordinary auriferous deposits, inasmuch as the material filling the ore-channels does not differ greatly in appearance from the 'country' rock, and is but slightly mineralized. The 'country' rock is 'pyrophyllite schist,' associated with 'felspar-porphyry,' sometimes turning into 'quartz-porphyry,' the whole being tilted at a high angle. The bedding and cleavage-planes appear to be coincident. The rock forms lenticles both microscopic and macroscopic. Some of the lodes are accompanied by a quartz 'indicator' which contains little or no gold in itself, the precious metal being found in the shattered 'country' rock of its foot-wall. On the foot-wall side this shattered zone gradually merges into the ordinary 'country' rock. The cause of the parallelism of the auriferous lodes, the mountain-ranges, and the seacoast is discussed, and it is pointed out that the gold does not occur in large grains.

CORRESPONDENCE.

THE ROCKS OF SOUTH DEVON.

Sir,—In Professor Bonney's unfriendly criticism of my paper on the Devonian rocks of South Devon, in the October Number of the Geological Magazine, I am taxed with the commission of three faults among other failings, viz :—

(1) The avoidance of certain apparently possible alternatives which my critic deems of importance.

(2) The not having studied a Devonshire problem in "other fields than South Devon."

(3) The having attempted a research with insufficient materials.

In reply to the first I may state that had I been able to discuss Prof. Bonney's South Devon paper, the points referred to by him would have been satisfactorily disposed of; but I was unable to discuss that paper for the following reason. In October, 1891, Prof. Bonney volunteered to me the statement that he did not mean to enter into any controversy on the subject (of the Devon schists) until his shield was struck by a knight of equal experience. Under the circumstances I had no option but to leave the Professor and his paper alone.

With respect to the second objection, it is evident that the affinities between two sets of Devonshire rocks can only be studied in Devonshire, and not elsewhere. My subject was much more restricted than my critic seems to suppose.

Respecting the charge of insufficiency of materials for research, Prof. Bonney is scarcely in a position to find fault, seeing that he dismissed the whole of the complicated Start headland with the cursory observation—"Two specimens from different parts of the Start headland call for no special remark" (Q.J.G.S. vol. xl. p. 15). Your readers will scarcely be able to realize the significance of this naïve remark.

Southwood, Torquay,
16*th November*, 1892.

A. R. Hunt.

GLACIAL GEOLOGY.

Sir,—I have read with much interest the papers by Mr. Mellard-Reade and Mr. Percy Kendall in your July and November issues. On the one hand we have the submergence theory proved up to the hilt, and on the other the glacier theory sustained with equal show of reason. Does it not strike the combatants that they may both be right and both be wrong? For at one time during the Pleistocene Period the land was certainly deeply submerged in the sea, whilst at another it was with equal certainty enveloped in ice.

There are one or two points in Mr. Kendall's paper to which I should like to refer. Soon after the late Dr. Carvill Lewis came to England, I had the pleasure of showing him the principal sections of Boulder-clay and sand in the Trent Basin, and I think I convinced him that even if there is "a commingling of the Drift" in some deposits in that area, there is also an equally marked absence of com-

mingling in other Drift deposits of the same area. If Mr. Kendall were to try to explain the distribution of the rocks in the Drifts of the Trent Valley on the glacier theory alone he would be in even greater difficulties than he is at present.

Mr. Kendall is not quite accurate in implying that Dr. Carvill-Lewis was the originator of the idea that the valley of the Trent formed a large lake at one time. This was clearly stated in a paper read by me before the Geological Society in 1886. In that paper I make the Middle Pleistocene Epoch open with a "land locked and probably ice-locked" . . . . "Melton-sand sea." Indeed the idea is used to explain the absence of mollusca in the deposits of this epoch. Dr. Carvill Lewis, I think, held that the water level in this sea or lake was above that of the Atlantic; but the facts rather support the view that it was connected with the outside sea, the watershed of Central England being submerged several hundred feet.

It appears to be quite time that the advocates of glacier theories and submergence theories joined hands for the purpose of ascertaining if a more careful study of the "Glacial Succession" will not reconcile their present conflicting views.

R. M. Deeley.

10, Charnwood St., Derby, *Nov. 15th*, 1892.

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—In the September Number of the Geological Magazine (p. 405) Sir Henry Howorth writes: "I claim to have shown that, as tested by these islands, the Mammoth beds are in every instance overlain by the Drift, and are never underlain by it;" this claim being limited to cases where it is possible to apply the test of superposition. In my letter of October, I took two of his cases and showed that in both the beds enclosing Mammalian remains were underlain by Glacial Drift, *i.e.*, that the main mass of the local Boulder-clay passed beneath them; thereby disproving the verbal accuracy of his statement.

Again, on p. 400, he discusses the gravels in the valley of the Ouse, near Bedford, a case by the way in which the test of superposition does not apply. In this connection he quotes the discovery of flint-implements "at Thetford on the Ouse," and a few lines lower down he "turns to another site *in the same valley*," being one not far from Bedford (italics are mine). Replying to my obvious comments on this he says he has nothing to correct and nothing to alter in what he wrote, except the spelling of a word, and that the point is "only a test of my knowledge of the English language!" I feel sure your readers will by this time have seen that it was really a test of Sir H. Howorth's knowledge of English geography, and, as I said, of his practical acquaintance with the subject. I did not expect that I should be called upon to point out that the valley of the Little Ouse, between Norfolk and Suffolk, is entirely different and distinct from the valley of the Great Ouse, near Bedford! Not even Sir H. Howorth's approved ingenuity in the use of the English language can make them parts of one and the same valley. There

is a Thetford on the Great Ouse, but that is not the place in question.

I do not deny the desirability of his making himself acquainted with the literature of the subject, and a précis of it would be a useful introduction to any detailed memoir on the Pleistocene Deposits; but I do deny that quotations from published papers, however numerous, form a reasonable ground on which to base a claim of having upset the generally accepted views of geologists on any given point.

Neither is it sufficient to deal only with the cases where the test of superposition can be applied; he practically admits this, by referring to the valley of the Great Ouse, but gravels containing Mammoth remains occur in many other valleys which are generally considered to have been eroded out of a wide-spread mantle of Glacial Drift, and this conclusion is not shaken by anything which Sir H. Howorth has written.

Sir Henry may have visited many places and have looked at many sections, but it does not follow that he is qualified to draw sound geological inferences from the phenomena before him. I should be loth to find fault with any one who is seeking to ascertain the truth, but it is the assumption that he has already found the truth by merely sifting the literature of the subject that I venture to protest against.

I feel perfectly sure that if I pointed out a clear case of gravels with Mammoth bones resting on Boulder-clay, Sir H. Howorth would not accept it as final; he would say there might have been another Boulder-clay originally over the gravel, as is supposed by some to be the case at Hoxne.

The question, together with others relating to the glacial deposits, will some day be settled beyond dispute by a man who has acquired an insight into the subject by long experience and by approved practical work in the field, and I am content to await his appearance.

EXETER, *Nov.* 10, 1892. A. J. JUKES-BROWNE.

OBITUARY.

WE regret to announce the death of Mr. Henry John Marten, M.Inst.C.E., F.G.S., etc. Mr. Marten was a well-known hydraulic engineer. He had been engineering adviser to the Board of Agriculture, engineer to the Severn Commissioners and to the Staffordshire and Worcestershire Canal Co. So recently as October 7, he gave evidence before the Royal Commission on Water Supply, on the practicability of constructing storage reservoirs in the Upper Thames Valley. In 1890 he read before the Geological Society a paper "On some Water-worn and Pebble-worn Stones taken from the Apron of the Holt-Fleet Weir on the River Severn" (Quart. Journ. vol. xlvii. p. 63). Mr. Marten died November 3rd, in his 66th year.

Thomas John Moore, A.L.S., Corr. Memb. Z.S.—We regret to record the death, on October 31st, of Mr. T. J. Moore, for forty years the esteemed curator of the Liverpool Museum. Born in London in 1824, Mr. Moore early evinced an interest in scientific pursuits, and was at the age of nineteen appointed assistant to Mr. John Thompson, curator of the Earl of Derby's Museum at Knowsley. In 1851, when this collection was bequeathed to the Corporation of Liverpool, Mr. Moore became curator, a position he held until the end of last year, when failing health compelled him to tender his resignation. Though more deeply interested in Zoology and Comparative Anatomy than in Geology and Palæontology, Mr. Moore devoted his energies to the perfection of every department of the Museum under his charge, more especially enlisting the services of the sea captains in obtaining acquisitions; and Liverpool at the present time has thus one of the finest and best-arranged of provincial museums. Besides contributing numerous notes on Zoological subjects to scientific journals, and providing material for many specialists who recognized him as a valued collaborator, Mr. Moore took an active part in the spread of scientific teaching among the people, and his popular lectures were always highly appreciated. From 1865 to 1884 he organized the Liverpool Free Public Lectures; and he was an active member of all the bodies in the city devoted to the encouragement of scientific research.

MISCELLANEOUS.

Bristol Museum and Library.—At a well attended meeting of the shareholders, held at the Bristol Museum and Library, Queen's Road, Bristol, on Thursday, November the 3rd, the shareholders adopted a resolution, recommended by the Council, for the transference of the institution to the Corporation of Bristol. The Museum Endowment Fund, £1,475, together with the generous offer of £3,000 made by Sir Charles Wathen, will permit the liabilities to be cleared off. The Buildings, Museum, and Library, are valued at from £30,000 to £40,000, but for some time past the income, derived chiefly from subscriptions, had been inadequate properly to carry on the work, and had gradually declined during the past ten years. By placing the Museum and Library in the hands of the Corporation, their proper maintenance in the future will be assured, and the officials will, it is to be hoped, be adequately paid for their services.

Geological Survey of New South Wales, Sydney.—We understand that Mr. Joseph E. Carne, F.G.S., Curator of the Mining and Geological Museum, Sydney, N. S. Wales, who so ably assisted the late Mr. C. S. Wilkinson, F.G.S., during the Mining and Metallurgical Exhibition at the Crystal Palace, Sydenham, in 1890, has been appointed by the Minister of Mines to the post of geological surveyor, with a salary of £400 per annum. Mr. Carne entered the service of the N. S. Wales Government in 1879, and has proved himself to be in every way a most able and efficient officer, and has won the esteem and regard of all with whom he has come in contact.

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